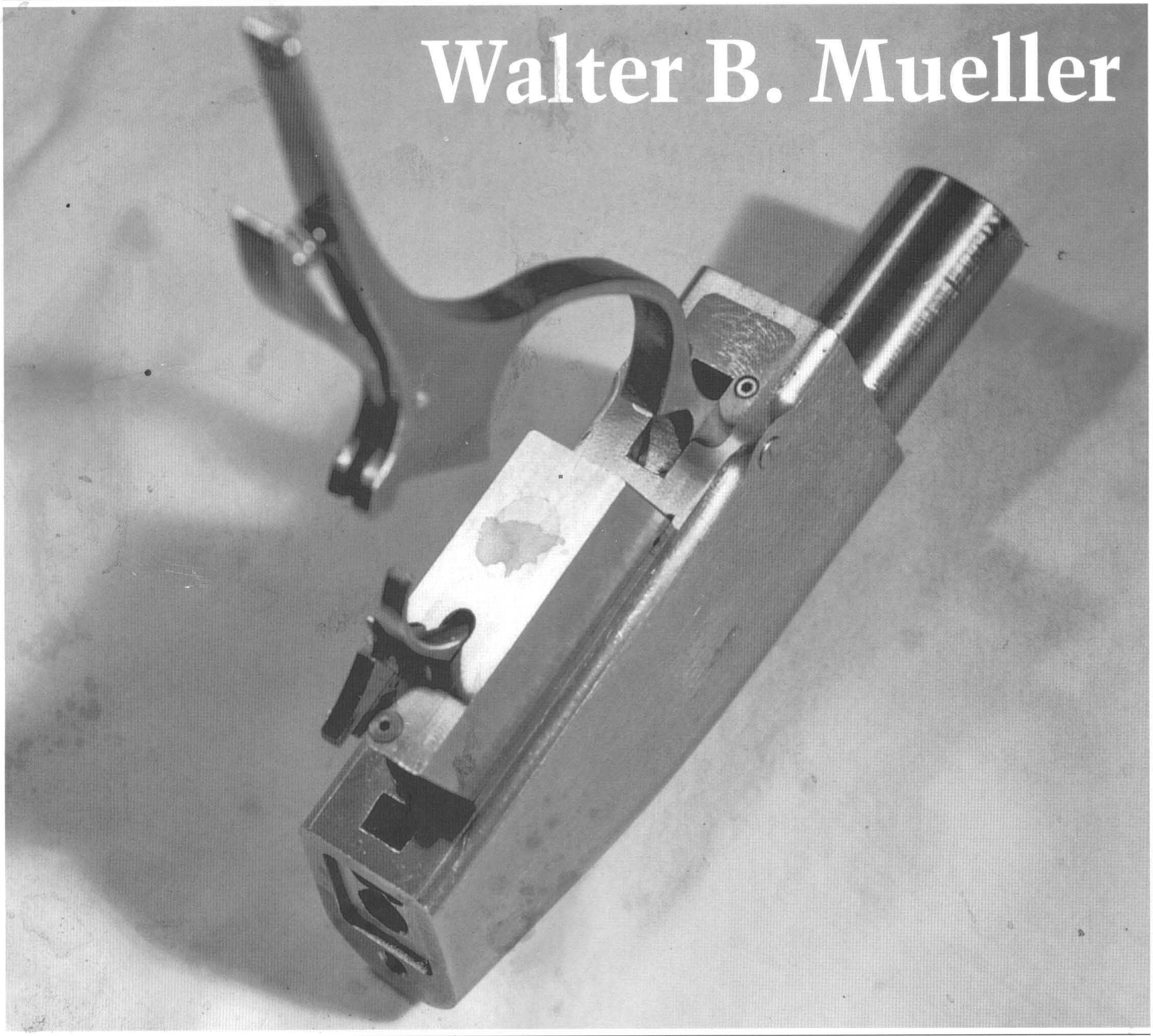
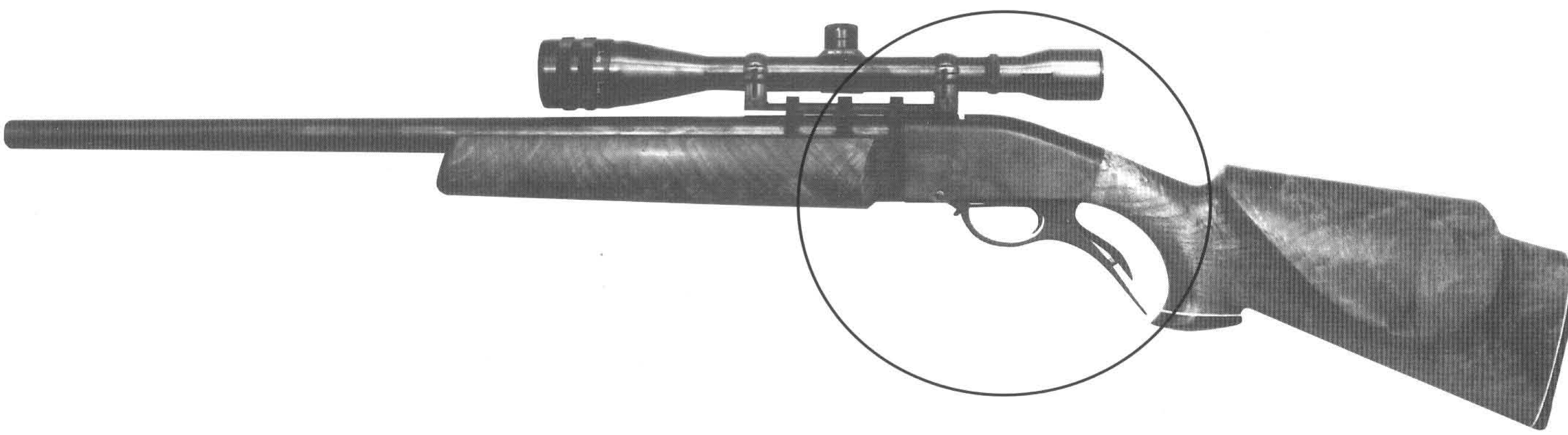
$14.50 U.S., $16.00 Canada



# Building a Single-shot, Falling-block RIFLE ACTION

# Building a Single-shot, Falling-block RIFLE ACTION

by
Walter B. Mueller



Village Press Publications, Inc.
Traverse City, Michigan

# Building a Single-shot, Falling-block RIFLE ACTION

by
Walter B. Mueller

A series of articles previously published in
*The Home Shop Machinist*



ISBN 0-941653-54-4
Library of Congress Catalog Card Number 98-073204

Editor
Joe Rice

Assistant Editor
Clover McKinley

Art Director
Luana Dueweke

Village Press, Inc.
2779 Aero Park Drive
Traverse City, Michigan 49686

# INTRODUCTION

Walter B. Mueller's series, first published in *The Home Shop Machinist* in 1994-1995, attracted a tremendous amount of interest, mail, and new subscribers. Word somehow got around the North American continent to gunsmiths and firearms enthusiasts that something new and exciting was being published. Back issues sold out within weeks. I believe we are intrigued by new and unique mechanical designs, especially if our interest involves gunsmithing and/or shooting. We want to know how it works, even if we never decide to build one ourselves.

Walter Mueller is not a gunsmith by trade, however. He is better identified as a firearms enthusiast who has vast experience in machining. None of his other articles published in *The Home Shop Machinist* have been firearms related. They are simply darn good articles about better ways to accomplish machining tasks or improve a machine tool you already have in your shop.

If you're looking for a new challenge in your own shop, or a more effective rifle action for benchrest shooting, you've come to the right place. You won't be disappointed.

Joe Rice, Editor

**1** ***The Mueller No. 1 rifle – the first of its kind in the world.***

## BUILDING A SINGLE-SHOT, FALLING-BLOCK

# *Rifle Action*

*by Walter B. Mueller*

Photos by Author

The data and design parameters presented in this article have been developed by the author and, using the carefully controlled manufacturing techniques described by him, have been proven to be safe as used in his (pictured) rifle. Although the author writes these manufacturing instructions using inclusive language, he does not necessarily recommend that any other worker attempt to duplicate his work. To those workers who may be skilled and knowledgeable enough to produce a mechanism of this complexity, the author states this warning. Know that you are fabricating a device that will contain potentially hazardous high pressures, that can cause serious bodily injury. Know also that you have exercised your own personal choice if you have decided to build and use this mechanism. Since neither the author nor the publisher can enforce proper material selection, dimensional control, methods of manufacture, workmanship standards, selection of acceptable cartridge, responsible and safe loading of the selected cartridge and heat-treatment results of other workers, they cannot and do not accept any liability, either expressed or implied, for results of damage or injury rising from or alleged to have risen from the data contained in these manufacturing instructions.

Described in this and the following chapters is the design and construction of a lever-action, falling-block, single-shot rifle action. As designed and shown, the action was built into a caliber .225 Winchester bench rest target rifle intended mostly for shooting range use (Photo 1). When fitted with the heavy barrel shown, the rifle weighs slightly more than fifteen pounds, making it rather heavy for field use. But, since I have no wish to kill any creature, it suits me very well. Further, as a pure target rifle, it fulfills its intended purpose in exceptional fashion, giving its maker great reason to grin. Should you choose to build this action and do it well, you could make the rifle of your dreams and also have some fun.

The general arrangement of the rifle action is shown in Photos 2 through 5. The photos show an operational Mueller No. 1 action in its rough, unpolished form and "in-the-white." If you fired this action and depressed the finger lever latch, lowering the finger lever, this sequence of mechanical actions would take place:

1) The nose of the firing pin is withdrawn from the indentation it formed in the primer.

2) A camming surface on the finger lever engages the striker, forcing it to the rear against the pressure of the striker spring, until the striker sear slips over the trigger sear, cocking the trigger as the breech block starts to lower.

3) A cam on the finger lever contacts the extractor, moving it rearward in its guide, extracting the fired case from the chamber.

4) A camming surface on the safety slide rod pushes the automatic safety forward, immobilizing the trigger.

5) At this point, the shooter picks the fired case from the chamber and disposes it to the ammunition holder block and gets a live round, inserting it into the chamber.

6) The finger lever is now started upward and the breech block rises, camming the cartridge

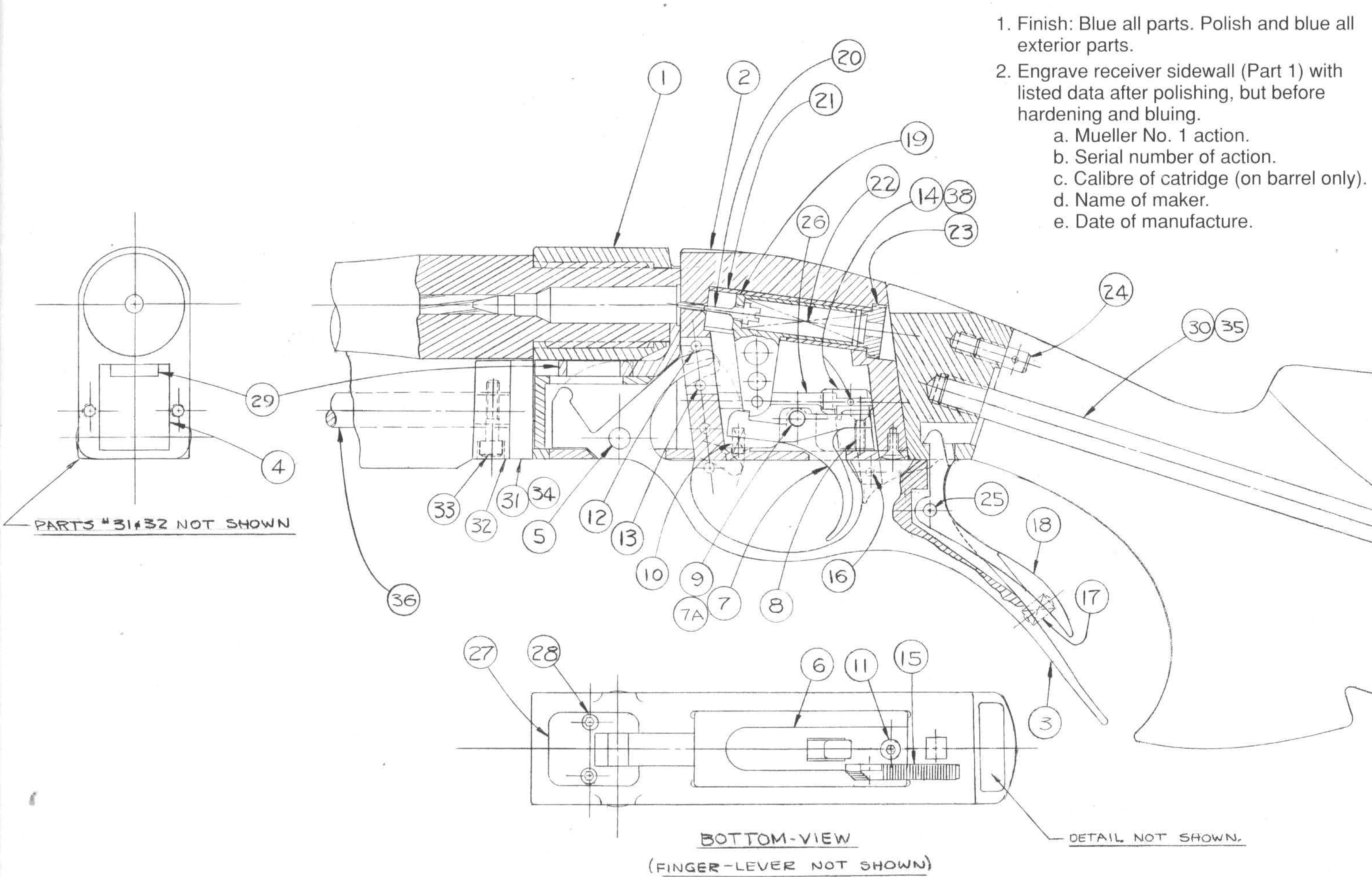
**2** ***The left side of the rough, unpolished action.***

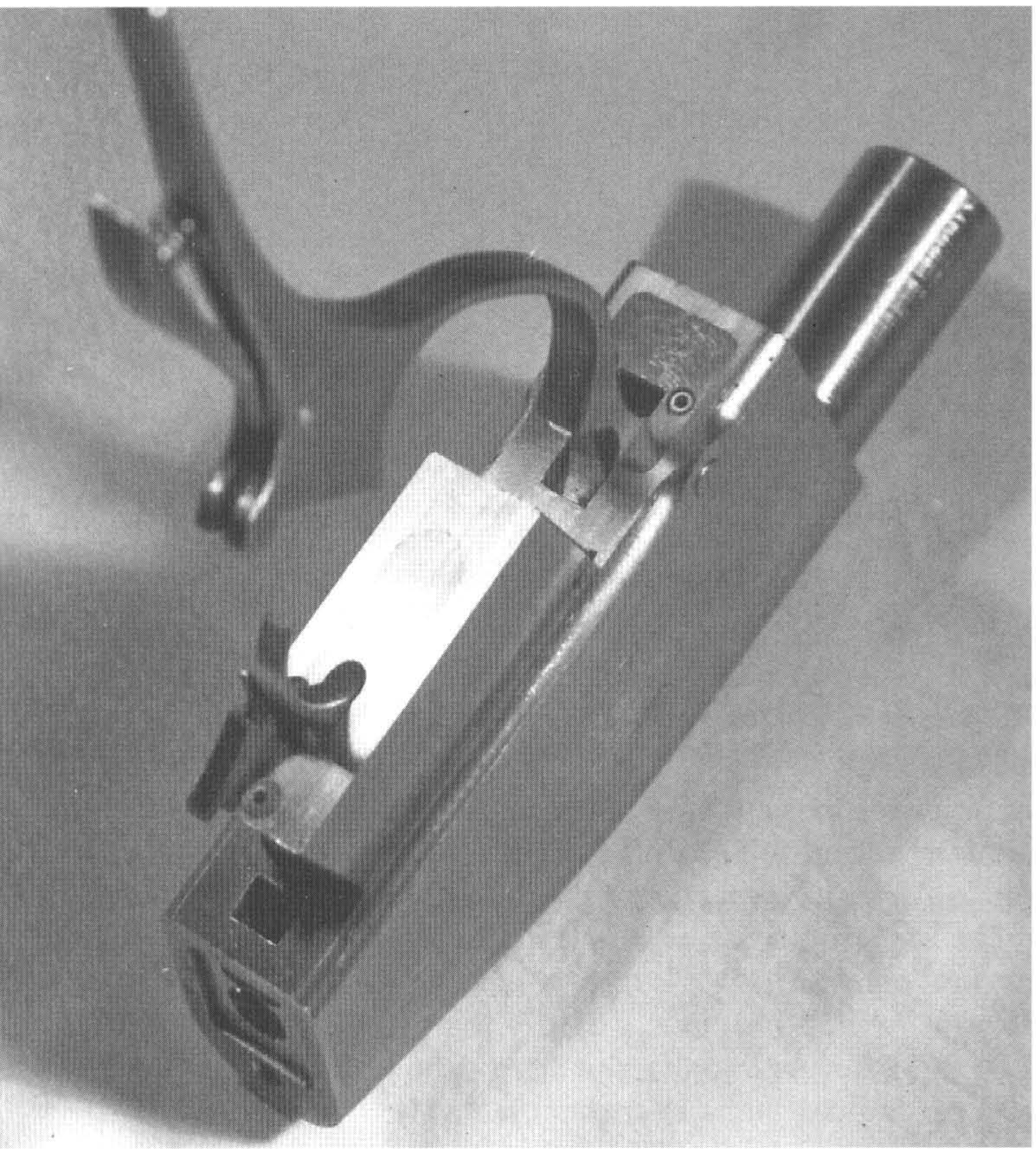
**3** ***The right side of the action. The safety button appears just behind the base of the trigger.***

into the chamber and returning the extractor to its ready position.

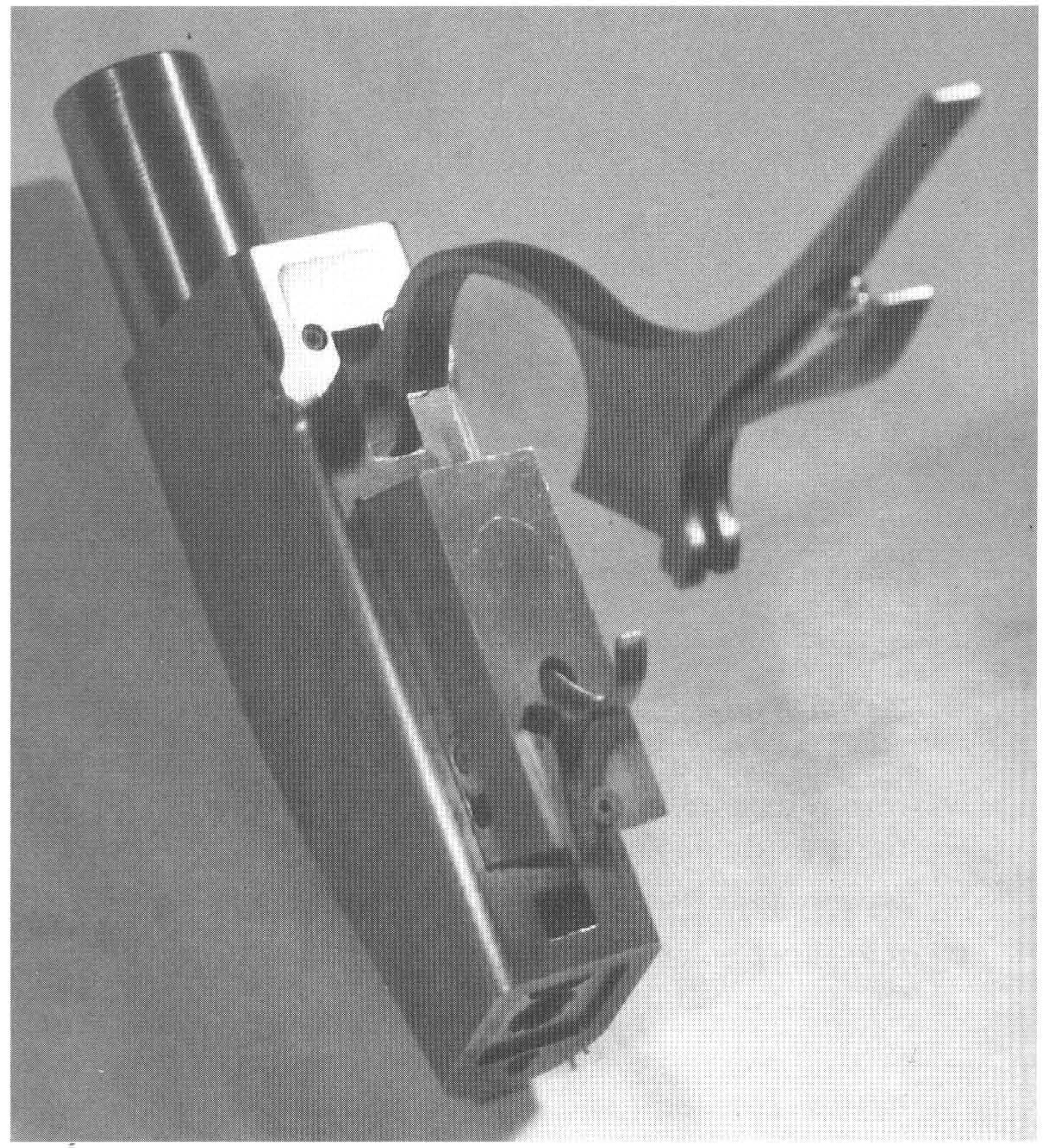
7) The shooter pushes the safety button to its rear-most position, the trigger is enabled and the action can be fired.

With the exception of the finger lever, safety button, extractor and finger lever latch, all of the above functions (except step 5) are performed by mechanism contained entirely within the breech block. As may be seen from the assembly drawing, the breech block has mostly solid front, rear and side walls. Its large opening is on the bottom, which provides a cavity that accepts the trigger mechanism, the auto-safety assembly, and the firing pin and striker assembly.





**4** ***The bottom side of the action is shown with the finger lever in its lowered position.***



**5** ***The action, with the finger lever lowered, is shown from the back side. Visible are machining details of the receiver back side, breech block, finger lever and finger lever latch.***

The breech block is enclosed by the trigger plate, which is held in place by a single screw. The entire operational mechanism is made up of only 29 parts, making it one of the simplest actions of its kind. An additional nine parts support stock and forearm attachment and the recommended telescope mounting.

An unusual design feature is the provision made to adjust the head space of the action, at first assembly and later, should the action ever "shoot loose." The photos portraying the overall views of the action show a stub barrel installed in the receiver. This barrel is really a construction tool. When properly fitted to the action, the stub barrel causes the breech block to be wedged in place between the barrel face and the rear wall of the receiver. The finger lever must position the breech block at this correct height. To achieve this required breech block position, the middle diameter of the breech block close pin (Part 12) is machined to the specific size needed by the finger lever camming surface, to bring the breech block to its light interference fit position. If the rifle chamber has been accurately machined, this leaves the action with virtually "zero head space." This is one of the factors that must be controlled if accurate shooting performance is to be expected from the rifle. Incidentally, an axial hole drilled lengthwise through the barrel also gives the correct location of the firing pin hole to be transfer-punched into the face of the breech block.

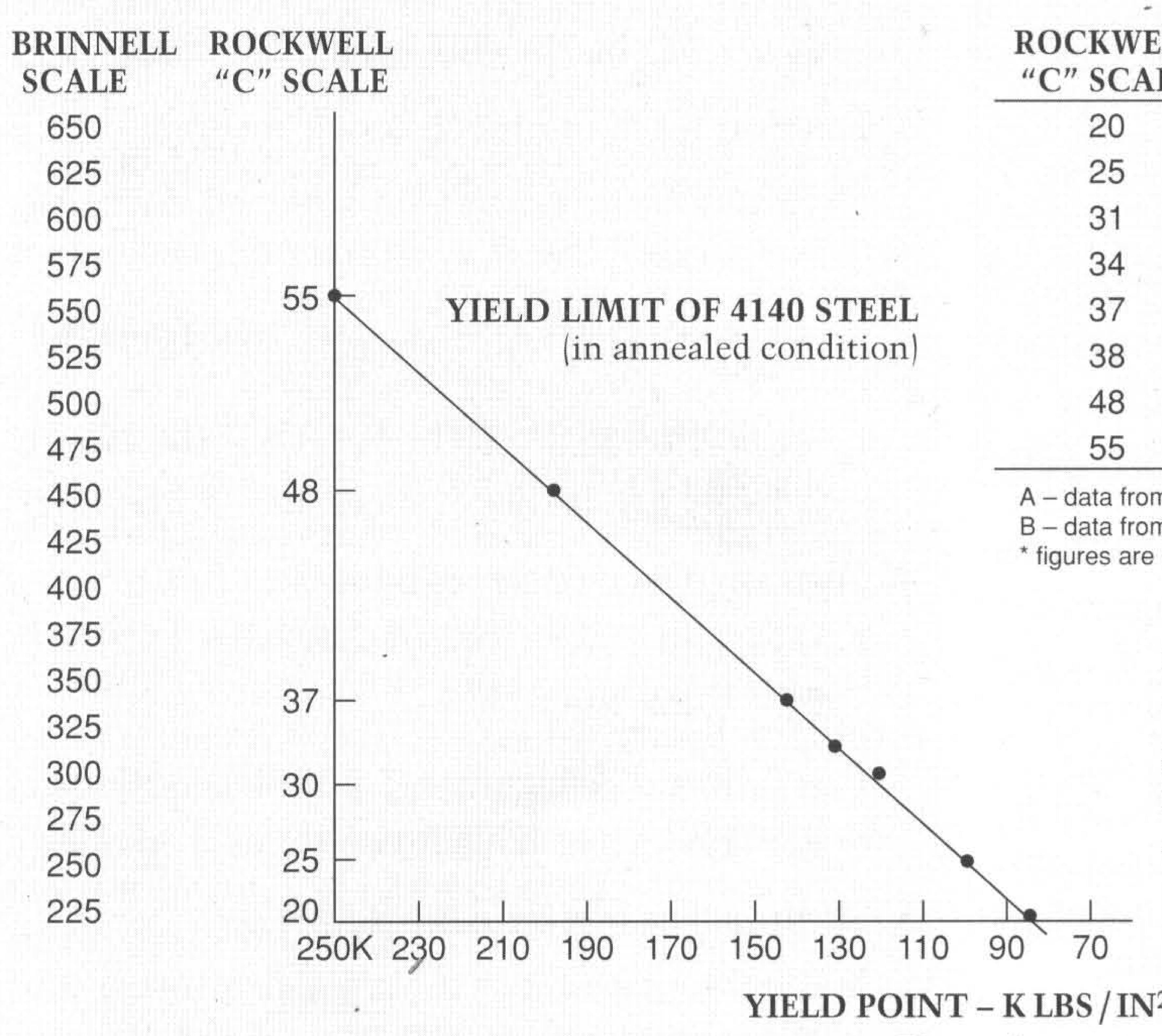
What may be an unusual departure in an article of this kind are numerical calculations that analyze salient design features of this action. This analysis is an investigation that precedes any model shop or manufacturing activity, and is intended to uncover deficient areas of the mechanical design. Since no experienced engineer would design a mechanism that cannot support its function, all inventive effort must be backed up by a set of calculations that consider, in detail, operational stresses the mechanism will experience. Not all parts of the mechanism are equally involved, but those items that feel significant stress levels must certainly be investigated to ensure their ability to withstand the imposed loads. In a mechanism containing explosive forces, the importance of such analysis cannot be minimized. Since your safety is of foremost consideration, these calculations are included for your consideration and understanding. Not everyone is educated to understand the methods and practice involved in the application of engineering theory, but please understand that this engineer

is concerned about the bodily safety of all.

The primary areas of concern in this analysis are the finger lever, receiver, breech block and the barrel shank. Considered first is the material used to make the receiver and breech block. This material is SAE 4140 steel, a strong, even-hardening variety that is the mainstay of firearms manufacture. Since it must be heat-treated to enhance its strength, the chart of Figure 1 shows how material hardness affects the yield point strength of the steel. The receiver and breech block calculations investigate the locking forces experienced by the action at the moment of highest pressure in the firing cycle. As they show, there can be no opening force imposed on the breech block that would cause it to move at the moment of firing. Finally, the barrel shank calculations detail the material stress in the barrel and form the basis for the choice of a 1.000" diameter barrel shank. There is no compromise with safety.

Following is a mathmatical analysis of critical design features as found on the Mueller No. 1 rifle action.

**HEAT TREATMENT OF SAE 4140 STEEL**




| ROCKWELL "C" SCALE | BRINNELL SCALE | YIELD POINT* | ULTIMATE STRENGTH | |
|---|---|---|---|---|
| 20 | 226 | 85 | 110 | A |
| 25 | 253 | 100 | 125 | A |
| 31 | 294 | 116 | 142 | A |
| 34 | 319 | 132 | 152 | A |
| 37 | 344 | 145 | 170 | A |
| 38 | 353 | 155 | 180 | A |
| 48 | 455 | 200 | | B |
| 55 | 558 | 250 | | B |

A – data from *Machinery's Handbook*, 13th ed., pages 1558, 1568, and 1569
B – data from Honeywell, Inc., metallurgical lab, P. Gustafson, 3/8/82
* figures are in thousand lbs/in$^2$

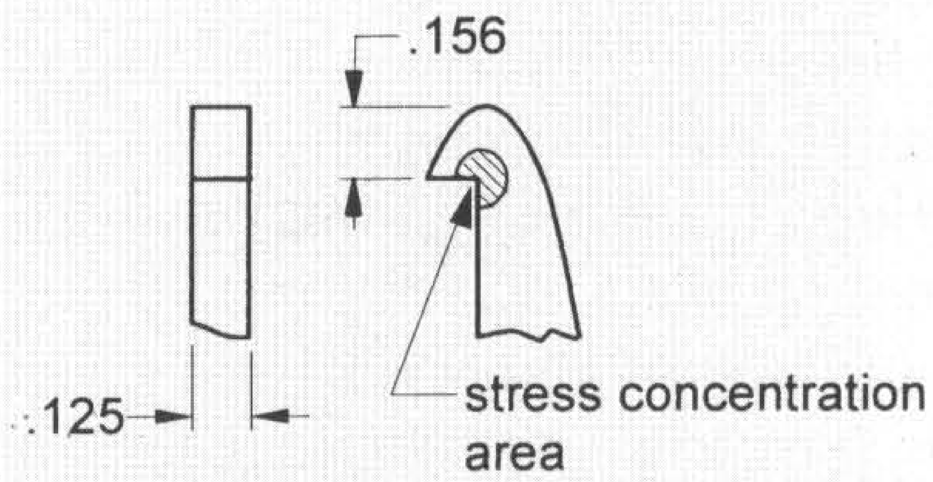
Receiver and breech block were "mar-tempered."
1) Pre-heat in air oven at 1000°F for (1) hour.
2) Soak in salt-bath at 1450°F for (3) hours.
3) Quench in oil at 400°F – hardness: 55 $R_C$.
4) Draw at 750° for (2) hours – hardness: 48 $R_C$.

*Figure 1*

**RECEIVER/BREECH BLOCK DESIGN CONSIDERATIONS**

Much thought was lavished on the design of the breech block and its relationship to the rifle receiver. It is a safety imperative that the breech block never move during the firing cycle and one would suppose this requirement dictates a solid mechanical lockup of the breech block to the receiver. But this is not necessarily true. Two falling block rifle actions come to mind: the Winchester high and low sidewall actions and the German-made Lechner, that depend primarily on a friction lock and only incidentally on a mechanical lock. Both of these actions feature a breech block that angles slightly rearward as the breech block moves downward. The Winchester blocks move at about a 6° angle and the Lechner at about 9°. Of course, what both of these designs make use of is the principle of the locking taper. Machine tool builders have long depended on Morse, Browne & Sharp, and Jarno tapers for tool shanks, knowing no amount of pure side thrust (force) will cause loosening of a locking taper tool shank. If one assumes a (published) value of 0.149 for the coefficient of friction for smooth, hard steel on smooth, hard steel, the locking taper angle is found to be 8.5°. Other workers have found this accepted 0.149 value to be conservative, and for hard steel on hard steel, have safely used values of 0.158, giving a locking taper angle of about 9.0°.

Therefore, the Mueller No. 1 rifle action makes use of a 7.333° angle in the drop of the breech block. This is a doubly conservative locking taper angle that allows about 0.12" of powerful longitudinal camming action to both seat and extract a cartridge case. An extra, incidental mechanical lock is supplied by the finger lever latch (Part 18), that can withstand at least a 700 lb. downward thrust of the breech block. This is a safety factor consideration only, because no amount of force, directed down the axis of the barrel bore, can cause the breech block to move.




Part 18

Material: Type 0-1 tool steel:

Yield strength of material = 180,000 psi = (S)

*Stress concentration factor (K) assumed = 5.0

Area (A) = .125 × .156 = .0195 in$^2$

$(S) = \dfrac{(P)}{(A)/(K)}$ where (P) is load that can be sustained by hook without material failure.

$$180{,}000\ \text{lbs}/\cancel{\text{in}^2} = \frac{(P)}{.0195\ \cancel{\text{in}^2}/(K)}$$

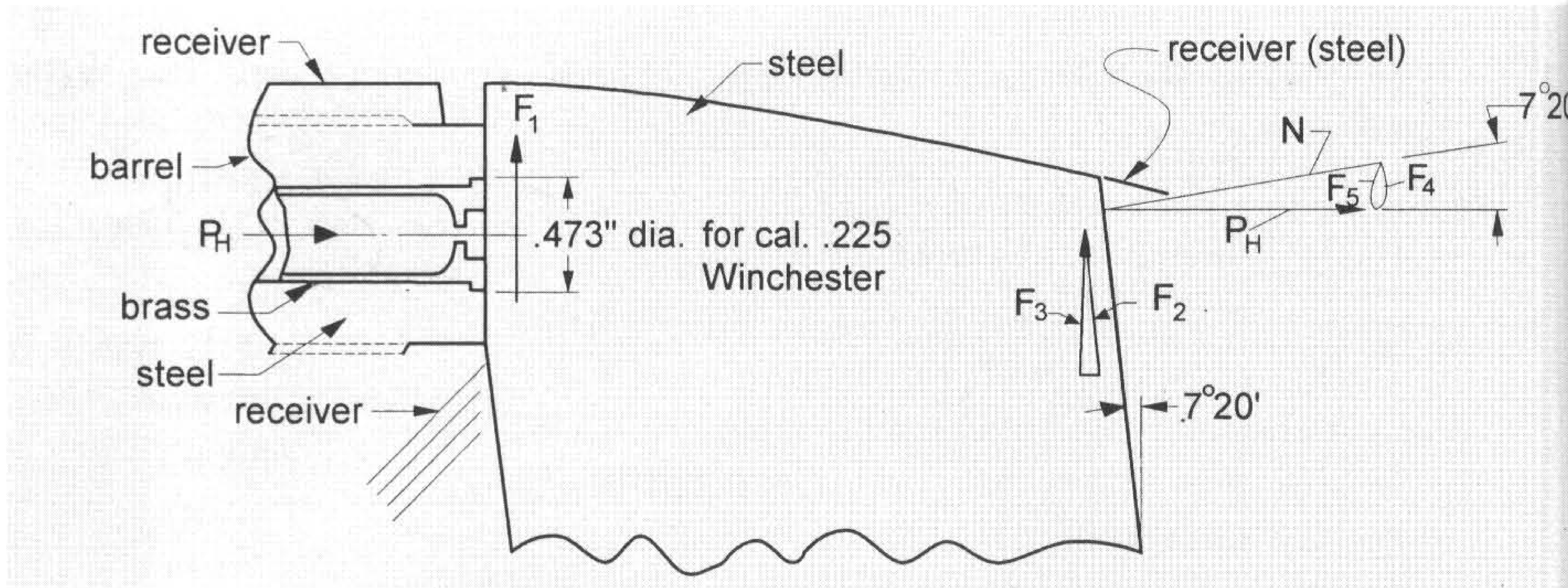
$(P) \cong 700$ lbs

*NOTE: Engineering handbook values for stress concentration factor (K) seldom exceed 5.0. This factor value is selected as conservative for a hook having a small (.01" typ.) radius in the throat area.

*Figure 2*

**RECEIVER/BREECH BLOCK DESIGN CALCULATIONS**

There is no published data showing chamber pressure vs. time for any combination of powder charge, bullet weight, case geometry and primer. About all anyone knows is that ignition starts, pressure rises, and the bullet is on its way, usually withing a half-millisecond or less. But a maximum pressure does occur in the firing cycle, and if we're lucky, the pressure will be less than 50,000 cup (copper units of pressure, similar to PSI). However, let's assume the worst and imagine that our maximum chamber pressure has risen to 65,000 psi. This is for design calculation purposes only, and should never be assumed to be a realistic or attainable chamber pressure, as the brass cartridge case material would certainly fail. At a design pressure of 65,000 psi, we would be very interested to find out what forces are being applied to the breech block/receiver assembly. So, let's calculate!




Assume:

1) P = 65,000 lbs/in$^2$ pressure

2) coefficient of friction – brass on steel ($\mu_1$) = .149

3) coefficient of friction – hard steel on hard steel ($\mu_2$) = .149 = ($\mu_1$)

1) Pressure against cartridge head: ($P_H$)

$$P_H = \left(\frac{.473}{2}\right)^2 \cancel{\text{in}^2} \times \pi \times 65{,}000\ \text{lbs}/\cancel{\text{in}^2}$$

$P_H = 11{,}421$ lbs.

2) Friction force of cartridge head against breech block:

$\mu_1 = \dfrac{F_1}{P_H}$: $\;.149 = \dfrac{F_1}{11{,}421\ \text{lbs.}}$

$F_1 = 1{,}701$ lbs. (resists breech block opening)

3) Friction force of breech block receiver face:

$N = P_H(\cos 7°20')$: $N = 11{,}421$ lbs. (.9918): $N = 11{,}327$ lbs.

$\mu_2 = \dfrac{F_2}{N}$: $\;.149 = \dfrac{F_2}{11{,}327\ \text{lbs.}}$: $F_2 = 1{,}687$ lbs.

$F_3 = 1{,}687$ lbs. ($\cos 7°20'$): $F_3 = 1{,}687$ lbs. (.9918) $= 1{,}673$ lbs. (resists breech block opening)

4) Opening force on breech block:

$F_4 = P_H(\sin 7°20')$: $F_4 = 11{,}421$ lbs. (.1276)

$F_4 = 1{,}458$ lbs.

$F_5 = F_4(\cos 7°20')$: $F_5 = 1{,}458$ lbs. (.9918)

$F_5 = 1{,}445$ lbs. (aids breech block opening)

5) Summation of vertical forces: ($F_V$)

$\Sigma F_V = F_1 + F_3 - F_5$:

$F_V = 1{,}701$ lbs. + 1,673 lbs. – 1,445 lbs.

$F_V = 1{,}929$ lbs. (resists breech block opening)

6) Conclusion: Breech block must stay closed during firing cycle.

*Figure 3*

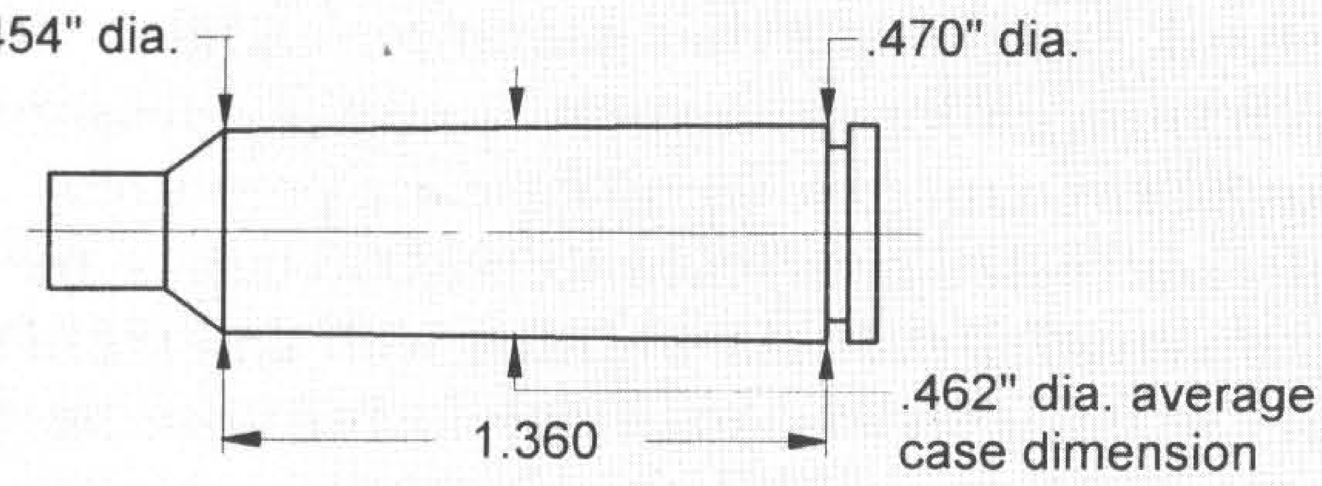
All of the above calculations make the simplifying assumptions that the only force active in the rifle chamber during the firing cycle is the rearward thrust of the shell casing on the breech block due to chamber pressure. Although this does not affect our conclusions concerning breech block closure forces, it is not the entire story. Other forces also act.

For you sophisticates, here is more (all?) of the picture. During the firing cycle, a number of things happen to the cartridge in the rifle chamber. In sequence, they are (assuming factory-fresh, unfired brass) as follows:

1) The firing pin strikes the primer, igniting it but also driving the cartridge case forward in the chamber until it is stopped either by the case rim or the case neck taper. This happens because the chamber is reamed to allow breech closure on a "go" gage and to refuse closure to a "no-go" gage. This can mean there is at least 0.003" of uncertainty in actual size. Additionally, all factory-fresh brass will usually freely enter a minimally sized chamber, so in a maximum "go" chamber, cartridge-to-chamber clearance can easily be as much as 0.005" or 0.006". Bolt actions using rimless cases are the worst examples of this problem. Since the Mueller No. 1 action stops the cartridge forward motion against the forward surface of the case rim, forward motion is minimized, usually being less than 0.003".

2) Rising internal case pressure forces the primer cup backwards, out of its pocket, until the primer cup movement is halted by the breech block. Still increasing internal case pressure causes the cartridge case sidewalls to expand and tightly grip the chamber walls, giving a (usually) gas-tight seal. The high internal case pressure also causes the cartridge case head section to stretch rearward until the case head contacts the breech block and is stopped. This stretching causes a thinning of the case wall just forward of the cartridge head, a condition usually found to be worst in bolt actions using rimless or rebated-rimless cartridges. This can have serious consequences for shooters who habitually full-length resize and reload fired brass, because continued case stretching will eventually thin the sidewall to the point of case/head separation. Bench rest shooters never full-length resize their brass, however, so this is rarely a problem for them.

It is interesting to calculate the effect of the internal high pressure on the case. Assuming a ridiculous pressure of 65,000 psi in the chamber, then, for a .308 Winchester case:




1) Area of case, excluding case neck and taper: (A)

$A = .462 \text{ in.} \times \pi \times 1.360 \text{ in.}$: $A \cong 1.974 \text{ in}^2$

2) Total gripping force of cartridge case wall to chamber: ($F_G$)

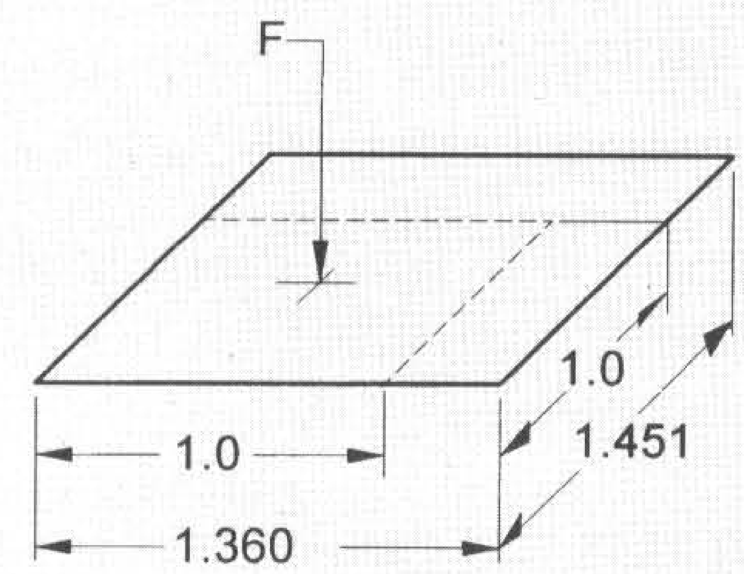
$F_G = A \times P$: $F_G \cong 1.974\ \cancel{\text{in}^2} \times 65{,}000 \text{ lbs}/\cancel{\text{in}^2}$

$F_G \cong 128{,}310$ lbs.

3) Assuming a friction coefficient ($\mu_3$) of .149, the friction force holding the cartridge case stationary in the chamber is: ($F_F$)

$\mu_3 = \frac{F_F}{F_G}$: $.149 \cong \frac{F_F}{128{,}310}$ $F_F \cong 19{,}118$ lbs.

Note: If you "slit" and unrolled the case, thus:




Force (F) on 1.00 square inch is 65,000 lbs. total

*Figure 4*

Ignoring the slight case taper and the small area forward of the case neck taper, the friction force holding the case stationary in the chamber is 19,118 lbs. This is why the case stretches and thins near the head.

The rearward force applied internally to the head area of the cartridge case is still 11,421 lbs., as calculated previously. This force is directly applied to the breech block, and reseats (and flattens, incidentally) the primer cup fully into the primer pocket of the case, as the case stretches to the rear.

Another effect of the extreme high pressure in the chamber is to cause plastic deformation of the brass in the cartridge case. Because of the extremely high unit stresses induced in the brass, the material is caused to flow. Being held immobile at the case head, the brass can only flow toward the case neck. This causes the case to get longer and thicker in the neck area – both unwanted consequences of high case pressure.

Even though all the design calculations for the No. 1 rifle action are based on chamber pressures of 65,000 psi, this is done only to arrive at barrel

shank dimensions that guarantee an adequate safety factor for the highest "normal" pressures to be encountered. In no case are pressures higher than a *maximum* of 55,000 cup to be generated. Read this warning well and HEED it. To do otherwise is to risk losing your head!

**RECEIVER SIDEWALL STRENGTH**

Let's look at the strength of the receiver sidewalls. The smallest sidewall section exists at the rear of the breech block slot. Sidewall height here is about 1.8". Sidewall thickness is (1.288 - 0.875)/2 or 0.206", so:

1) Total sidewall area: (A)

$$A = .206 \text{ in.} \times 1.8 \text{ in.} \times 2 \qquad A = .742 \text{ in}^2$$

2) Sidewall stress: (S)

P = total force on sidewall = 11,421 lbs.

$$S = \frac{P}{A}: \quad S = \frac{11{,}421 \text{ lbs.}}{.742 \text{ in}^2} \qquad S = 15{,}390 \text{ lbs/in}^2$$

3) Safety factor: (S/F)

$$S/F = \frac{\text{material strength}}{\text{sidewall stress}}:$$

$$S/F = \frac{200{,}000 \text{ lbs/in}^2}{15{,}390 \text{ lbs/in}^2} \qquad S/F \cong 13.0$$

**BARREL STRESS CALCULATIONS ($\sigma$ = Sigma)**

In any internally pressurized thick-walled cylinder, two kinds of stresses are produced in the cylinder material. They are: 1) radial stresses ($\sigma_R$) and tangential, or "hoop" stresses ($\sigma_T$). These stresses are calculated by the following expressions that relate unit stresses to internal pressure and cylinder sidewall thickness dimensions.

$$1)\ \sigma_R = \frac{a^2\ P}{b^2 - a^2}\left(1 - \frac{b^2}{r^2}\right) \qquad \text{Equation 1}$$

$$2)\ \sigma_T = \frac{a^2\ P}{b^2 - a^2}\left(1 + \frac{b^2}{r^2}\right) \qquad \text{Equation 2}$$

where:
- P = internal cylinder pressure
- a = internal cylinder radius
- b = external cylinder radius
- r = a selected variable radius

These equations show that ($\sigma_R$) is always a compressive stress and ($\sigma_T$) is a tensile stress. This tensile stress is always greatest at the inner surface of the cylinder, and is calculated using Equation 3, below:

$$\sigma_T = \frac{(a^2 + b^2)\,P}{(b^2 - a^2)} \qquad \text{Equation 3}$$

Of vital importance, it should be noted that the maximum tensile, or "hoop" stress, is always much greater in value than is the internal pressure in the cylinder. To the uninitiated, this can be a big surprise! So let's calculate:

1) Calculate radial stress at chamber mouth: ($\sigma_R$)

$$\sigma_R = \frac{a^2\ P}{b^2 - a^2}\left(1 - \frac{b^2}{r^2}\right)$$

where:
- P = 65,000 lbs/in²
- a = 0.211 in. for .225 caliber Winchester case
- b = 0.500 in. for 1.0 in. dia. barrel
- r = 0.211 in. at chamber mouth and 0.500 in. at barrel shank OD

$$\sigma_R = \frac{(.211)^2 \text{ in}^2 \times (65{,}000 \text{ lbs/in}^2)}{(.500)^2 \text{ in}^2 - (.211)^2 \text{ in}^2}\left[1 - \frac{(.500)^2 \text{ in}^2}{(.211)^2 \text{ in}^2}\right]$$

$$\sigma_R = \frac{(.0445) \text{ in}^2\ (65{,}000 \text{ lbs/in}^2)}{(.25) \text{ in}^2 - (.0445) \text{ in}^2}\left(1 - \frac{.25 \text{ in}^2}{.0445 \text{ in}^2}\right)$$

$$\sigma_R = \frac{2{,}894 \text{ lbs.}}{.2055 \text{ in}^2}\ (1 - 5.618)$$

$$\sigma_R = -\ 65{,}000 \text{ lbs/in}^2$$

where:
the minus sign designates a compressive stress

This result is not surprising. It shows that the radial stress is exactly the same as the original chamber pressure.

2) Calculate radial stress at barrel shank OD:

$$\sigma_R = \frac{(.211)^2 \text{ in}^2\ (65{,}000) \text{ lbs/in}^2}{(.500)^2 \text{ in}^2 - (.211)^2 \text{ in}^2}\left[1 - \frac{(.500)^2 \text{ in}^2}{(.500)^2 \text{ in}^2}\right]$$

$$\sigma_R = \frac{(.0445) \text{ in}^2\ (65{,}000) \text{ lbs/in}^2}{(.2055) \text{ in}^2}\ (0)$$

$$\sigma_R = 0.00 \text{ lbs/in}^2$$

At the barrel shank OD the radial stress drops to zero.

Now, comes an important calculation for barrel shank stress. This set of numbers will tell us what the tangential or hoop stress at the chamber mouth is, and will let us know if our choice of a 1.000" diameter barrel shank was a good decision. Let's calculate!

1) Calculate the tangential or "hoop" stress at the chamber mouth ($\sigma_T$):

$$\sigma_T = \frac{a^2\ P}{b^2 - a^2}\left(1 + \frac{b^2}{r^2}\right)$$

where:
a, b and r are the same values as used before.

$$\sigma_T = \frac{(.211)^2 \text{ in}^2\ (65{,}000) \text{ lbs/in}^2}{(.500)^2 \text{ in}^2 - (.211)^2 \text{ in}^2}\left[1 + \frac{(.500)^2 \text{ in}^2}{(.211)^2 \text{ in}^2}\right]$$

$$\sigma_T = \frac{(.0445)\ (65{,}000) \text{ lbs.}}{(.2055) \text{ in}^2}\left(1 + \frac{.25}{.0445}\right)$$

$$\sigma_T = \frac{2{,}894 \text{ lbs.}}{.2055 \text{ in}^2}(1 + 5.6179)$$

$$\sigma_T = 93{,}193 \text{ lbs/in}^2$$

This result is the GOTCHA! Tangential stress is a lot more than the 65,000 psi chamber pressure. However, from Figure 1, the yield strength of SAE 4140 steel (that's what our barrel is made of) at 25 Rc is 100,000 psi. We have just squeezed under the yield strength limit of our barrel material.

Calculating the hoop stress at the outside diameter of the barrel shank in the same fashion gives: ($\sigma_T$)

$$\sigma_T = \frac{(.211)^2 \text{ in}^2 \ (65{,}000) \text{ lbs/in}^2}{(.500)^2 \text{ in}^2 - (.211)^2 \text{ in}^2}\left[1 + \frac{(.500)^2 \text{ in}^2}{(.500)^2 \text{ in}^2}\right]$$

$$\sigma_T = \frac{(.0445)\ (65{,}000) \text{ lbs.}}{(.2055) \text{ in}^2}\ (2)$$

$$\sigma_T = 28{,}150 \text{ lbs/in}^2$$

At the barrel shank OD, the hoop stress level turns out to be pleasingly moderate.

Even though, at a calculation pressure of 65,000 psi, it appears the action of the rifle, as designed, can stand the stresses generated, the previous warning given must not be ignored. Chamber pressures of 55,000 cup should never be exceeded because of the dangers attendant in material flow of the brass in the cartridge case, which causes work-hardening and case wall thinning of the brass. The thinning can only be guessed at and no information can be generated concerning the work-hardening problem. Please, do not take any chances. Stay with reasonable chamber pressures, as given in all the reloading manuals, and stay SAFE!

To illustrate what I insist on above, let's calculate the hoop stress for a chamber pressure of 50,000 psi. This is a reasonable value, but plenty high enough, as your fired brass will tell you if you look for flattened primers. Plugging the required values into the previously used formula gives:

$$\sigma_T = \frac{(.211)^2 \text{ in}^2 \ (50{,}000) \text{ lbs/in}^2}{(.500)^2 \text{ in}^2 - (.211)^2 \text{ in}^2}\left[1 + \frac{(.500)^2 \text{ in}^2}{(.211)^2 \text{ in}^2}\right]$$

$$\sigma_T = \frac{(.0445)\ (50{,}000) \text{ lbs.}}{(.2055) \text{ in}^2}\left(1 + \frac{.25}{.0445}\right)$$

$$\sigma_T = 68{,}708 \text{ lbs/in}^2$$

Barrel shank tangential stress is lowered from the previously calculated value of 93,193 psi to a value of 68,708 psi. The safety factor (S/F) now realized is:

S/F = 100,000/68,708

S/F = 1.455

S/F = 45%

With a safety factor of 45% and operating pressures in the range of 50,000 psi, reasonable design parameters have been established to provide for safety of operation.

### LOCKING TAPERS AND THE COEFFICIENT OF FRICTION

In the "Receiver/Breech Block Design Considerations" section of this engineering data, I referred to "locking taper angles" as used in "locking taper tool shanks." I also state that the locking taper principle is what keeps the breech block locked in place during firing of the Mueller No. 1 action. Mathematically stated, the MAXIMUM locking taper angle (MLTA) is:

MLTA = arctan of the coefficient of friction

where: 1) the coefficient of friction is the value (number) that pertains for the two materials involved in the locking taper; and 2) the arctan = "the angle whose tangent is."

For example, the coefficient of friction of smooth, hard steel rubbing on smooth, hard steel is given to be 0.149 in various engineering handbooks.

So: MLTA = the angle whose tangent is 0.149
= 8.4747°.

Since an R-8 milling machine collet always requires a bump on the collet draw bar to make the collet release, and since an R-8 collet is reputed to have a draw-in angle of 8.5°, it can be seen that this angle is invariably a locking taper. No amount of side thrust will ever cause this taper to loosen. In light of this fact, the Mueller No. 1 action uses an even shallower locking taper angle of 7.333° to further promote safety in use. Expressed numerically, this gives a factor of safety (S/F), as calculated below:

S/F = 8.4747/7.333

S/F = 1.156

S/F = 15.6%

If you wonder how I can be so sure an R-8 taper is 8.5°, the answer is I measured the angle. The collets can be seen to be close to 8.5°, but the angle measurement is hard to make accurately, and besides, who knows how much the collet springs open after it is slit? So, my measurement technique was to measure the spindle nose taper of an R-8 spindle, not the collet. The equipment used to make the measurement was a Browne and Sharp 0.0001" indicator and the digital readout scales of the

machine. The DRO, of course, could only read out in 0.0005" increments, but we're not talking Bureau of Standards stuff here.

My technique was to center the indicator under the spindle nose taper. Then I moved the machine table until the indicator read "0" at the large end of the taper surface. This table position became 0.0000 on the machine DRO. Then the machine table was moved to bring the indicator point about 0.200" *away* from the taper surface and the machine table was raised 0.700" so the indicator point was now inside the spindle taper. The machine table was again moved to bring the indicator back to "0." The new DRO reading of 0.1045" was then noted.

The tangent of the spindle nose taper was then:

$$\tan SNT = 0.1045/0.700$$
$$\tan SNT = 0.149285714$$
$$\arctan 0.149285714 = 8.4907^\circ$$

That's close enough for me, if it's okay with you!

**BIBLIOGRAPHY**


Timoshenko, S. – Strength Of Materials; Part 2, Advanced Theory and Problems, Second Ed. D. Van Nostrand Company Inc., NY (1941)

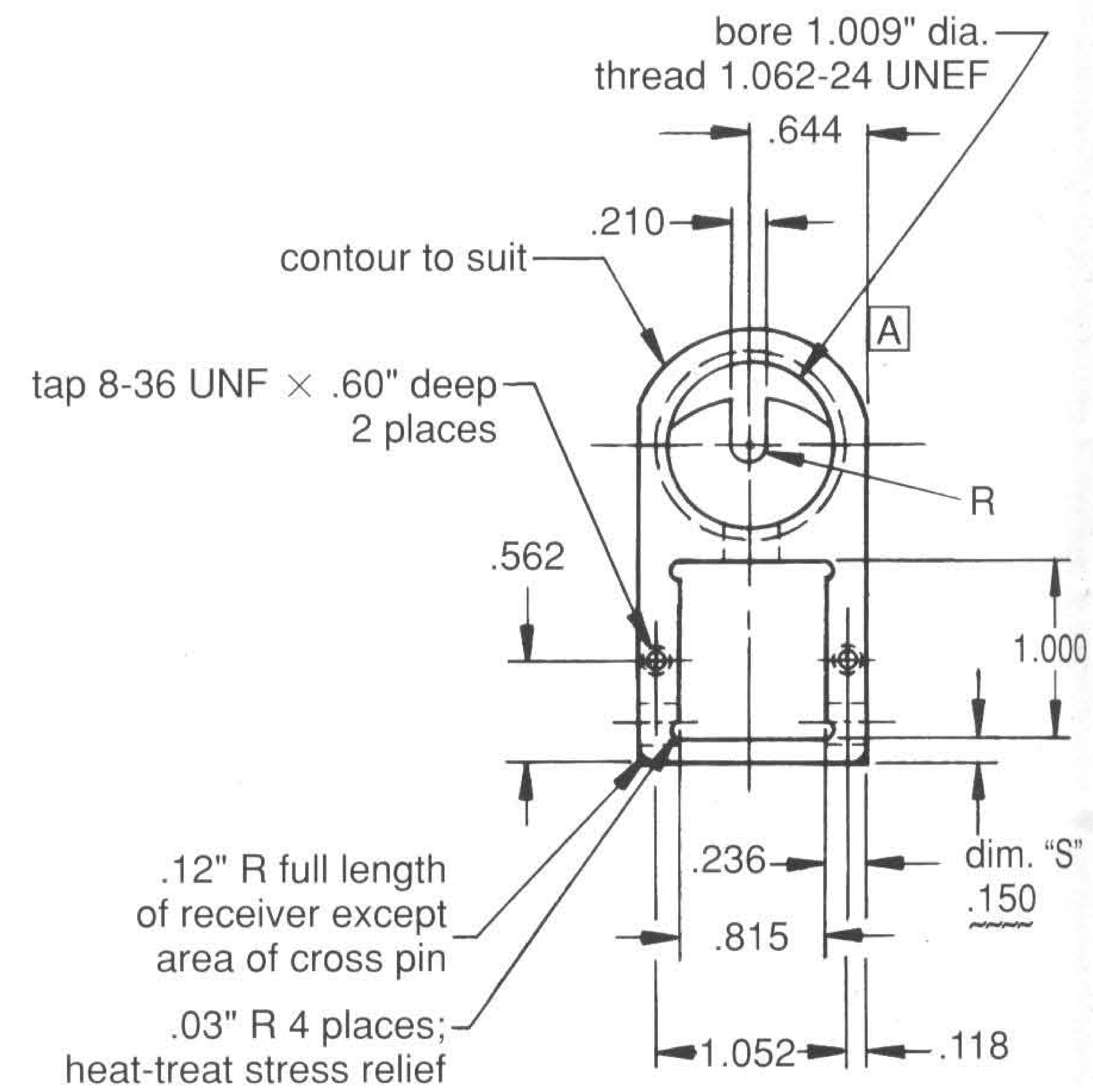
Laurson, P. G. and Cox, W. J. – Mechanics of Materials, Second Ed. John Wiley and Sons, Inc., NY (1948)

Maleev, V. L. – Machine Design, Revised Edition. International Text Book Co., Scranton, PA (1948)

Mc Lean, W. G., and Nelson, E. W. – Engineering Mechanics. Mc Graw-Hill Book Co., NY (1978)

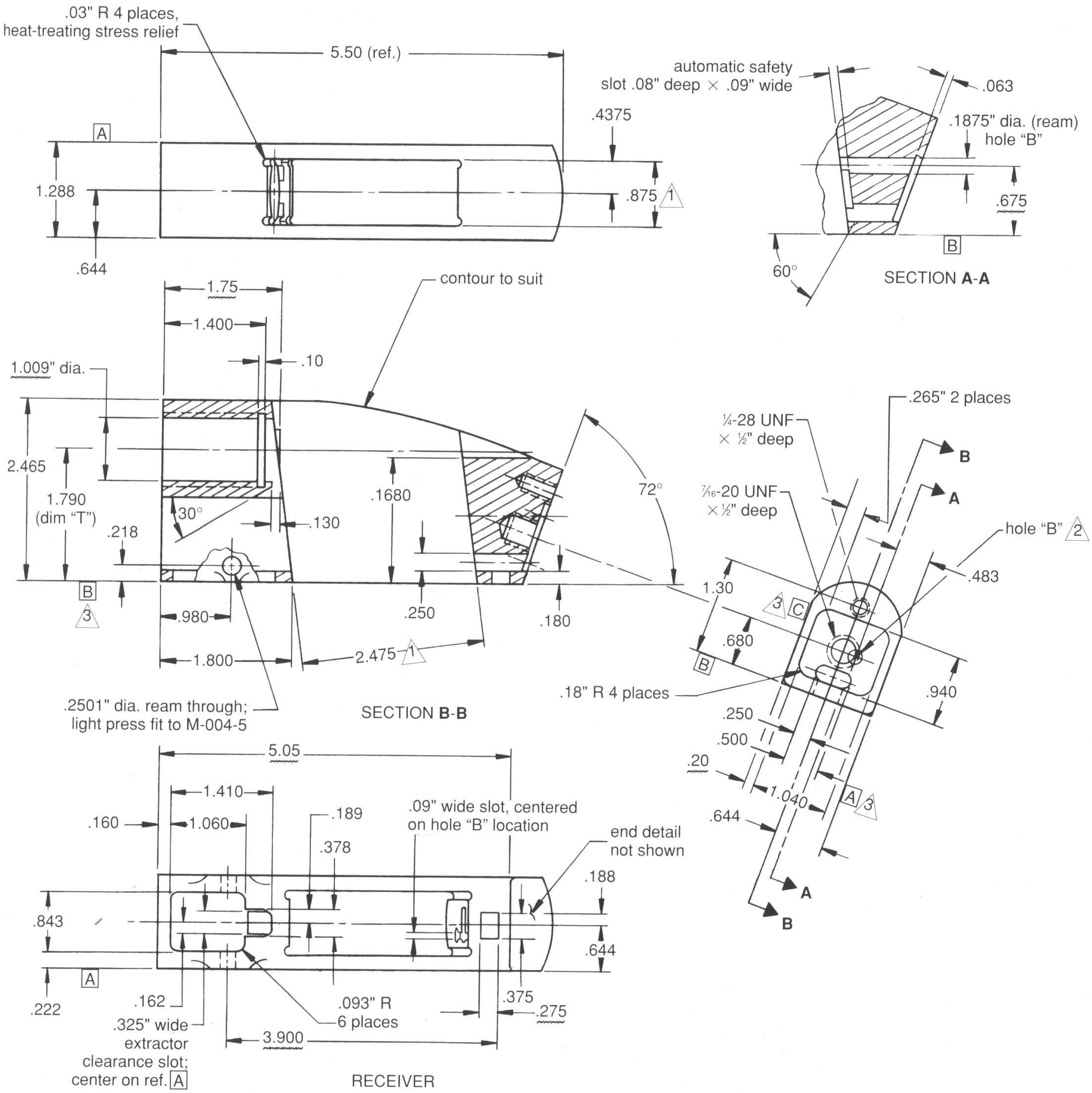
Hornady Manufacturing Company, Inc. – Hornady Handbook Of Cartridge Reloading. Grand Island, NE (1980)


With the design of the action explained and the computational analysis performed, it may be possible to consider, at this point, the construction of the action and what it can look like when it is incorporated into a rifle. The photo on page 2 shows what my rifle looks like. This is only one person's opinion about how a rifle should look. Your opinion may differ markedly from mine, and I would not be surprised if it did. The picture shows the receiver to have a gently curved upper contour that merges into the pistol-grip shape of the stock. There is no magic reason for this and the rifle builder can have any shape that pleases his eye. But I wish to insist that




| PART NO. | REQ'D. | PART NAME |
|---|---|---|
| 1 | 1 | Receiver |
| 2 | 1 | Breech block |
| 3 | 1 | Finger lever |
| 4 | 1 | Extractor guide |
| 5 | 1 | Cross pin |
| 6 | 1 | Trigger plate |
| 7 | 1 | Trigger |
| 8 | 1 | Trigger travel adjust screw |
| 9 | 1 | Trigger pin |
| 10 | 1 | Trigger spring |
| 11 | 1 | Trigger plate screw |
| 12 | 1 | Breech block close pin |
| 13 | 1 | Breech block open pin |
| 14 | 1 | Safety lever |
| 15 | 1 | Safety button |
| 16 | 1 | Safety button screw |
| 17 | 1 | Finger lever latch spring |
| 18 | 1 | Finger lever latch |
| 19 | 1 | Striker |

| PART NO. | REQ'D. | PART NAME |
|---|---|---|
| 20 | 1 | Firing pin |
| 21 | 1 | Striker sleeve |
| 22 | 1 | Striker spring |
| 23 | 1 | Striker sleeve lock nut |
| 24 | 1 | Stock stud |
| 25 | 1 | Finger lever latch pin |
| 26 | 1 | Safety slide-rod |
| 27 | 1 | Floor plate |
| 28 | 2 | Floor plate screw |
| 29 | 1 | Extractor |
| 30 | 1 | Stock bolt |
| 31 | 1 | Receiver dovetail anchor |
| 32 | 1 | Forearm dovetail |
| 33 | 1 | Forearm anchor screw |
| 34 | 2 | Receiver dovetail anchor screw |
| 35 | 1 | Stock bolt washer |
| 36 | 1 | Forearm support stud |
| 37 | 1 | Telescope mount |
| 38 | 1 | Safety lever screw |




RECEIVER
Part 1

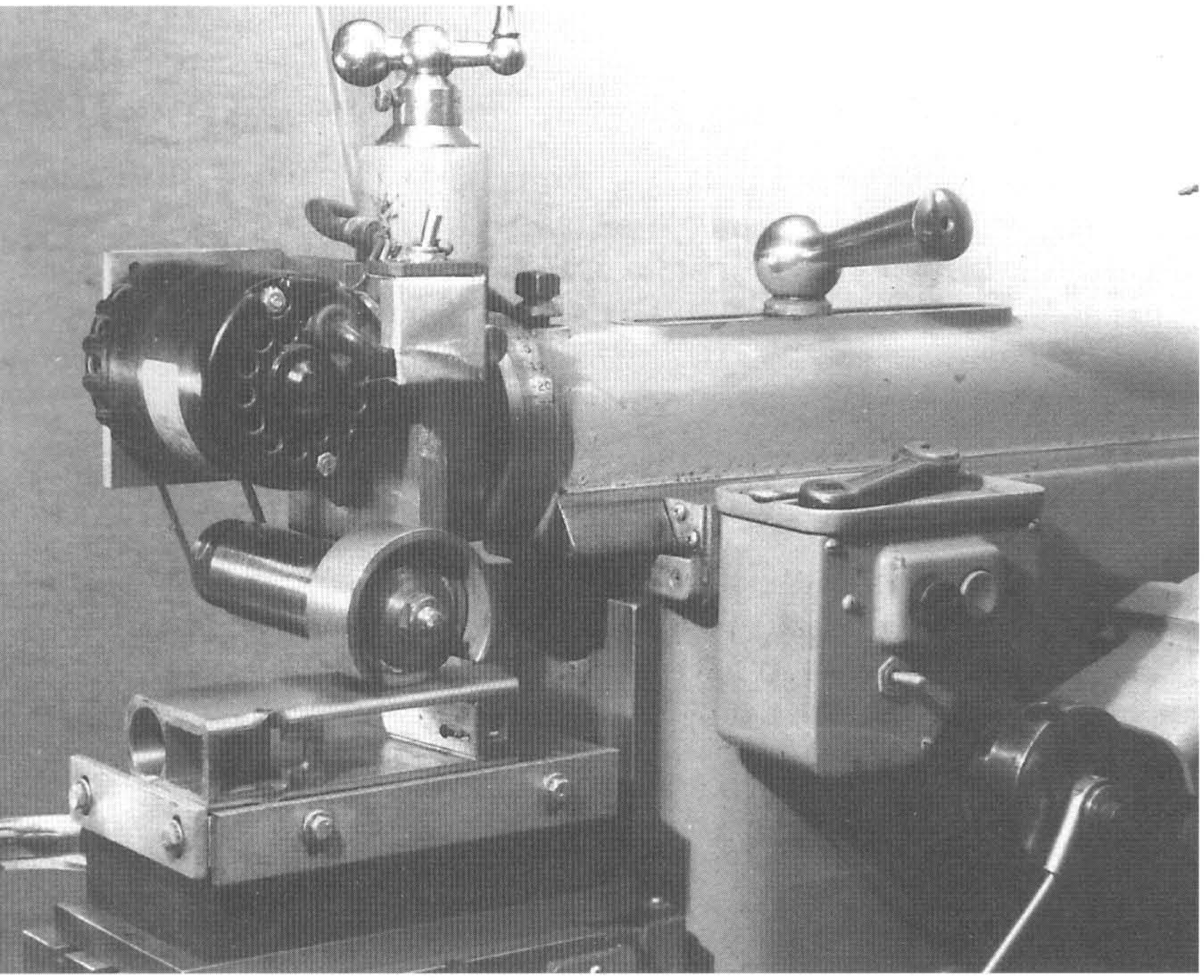
1. Material: SAE 4140 steel.
2. Heat treat: Pre-heat in air oven at 1000°F for 1.0 hour, then soak in salt bath at 1450°F for 3 hours. Quench in hot (400°F) oil. Draw at 750°F for 2 hours for 47-50 $R_C$ hardness.

△1 0.001" slip fit to M-002-2.

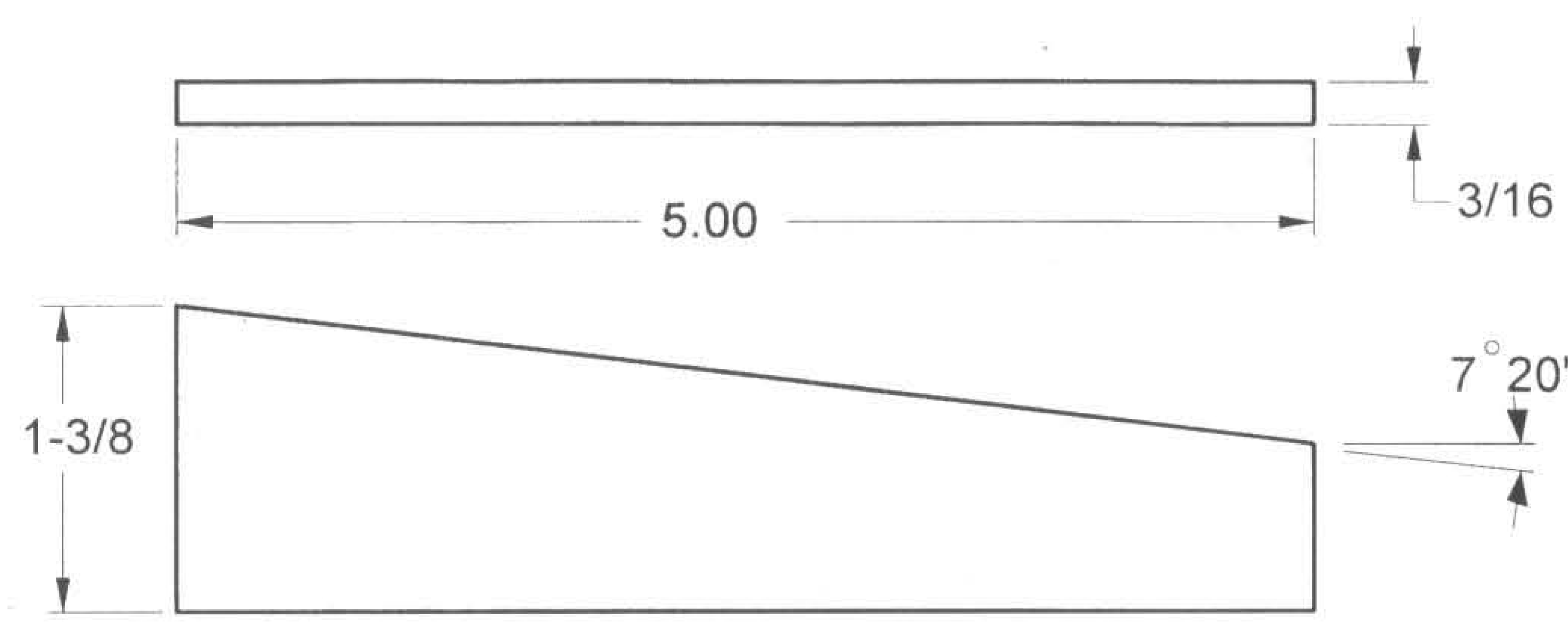
△2 End mill .188" dia. cut to bottom of 7/16-20 UNF threaded hole to provide starting surface for hole "B."

3. Reference [A] and [B] surfaces are the recommended machining location surfaces.

△3 .005" grinding stock left on surfaces "A," "B" and "C" for finishing material after hardening.



***6 Shown here is the grinding head I made for my South Bend shaper. It is valuable for the finishing operations on the hardened action parts.***




Tool 1
ANGLE BLOCK
CRS

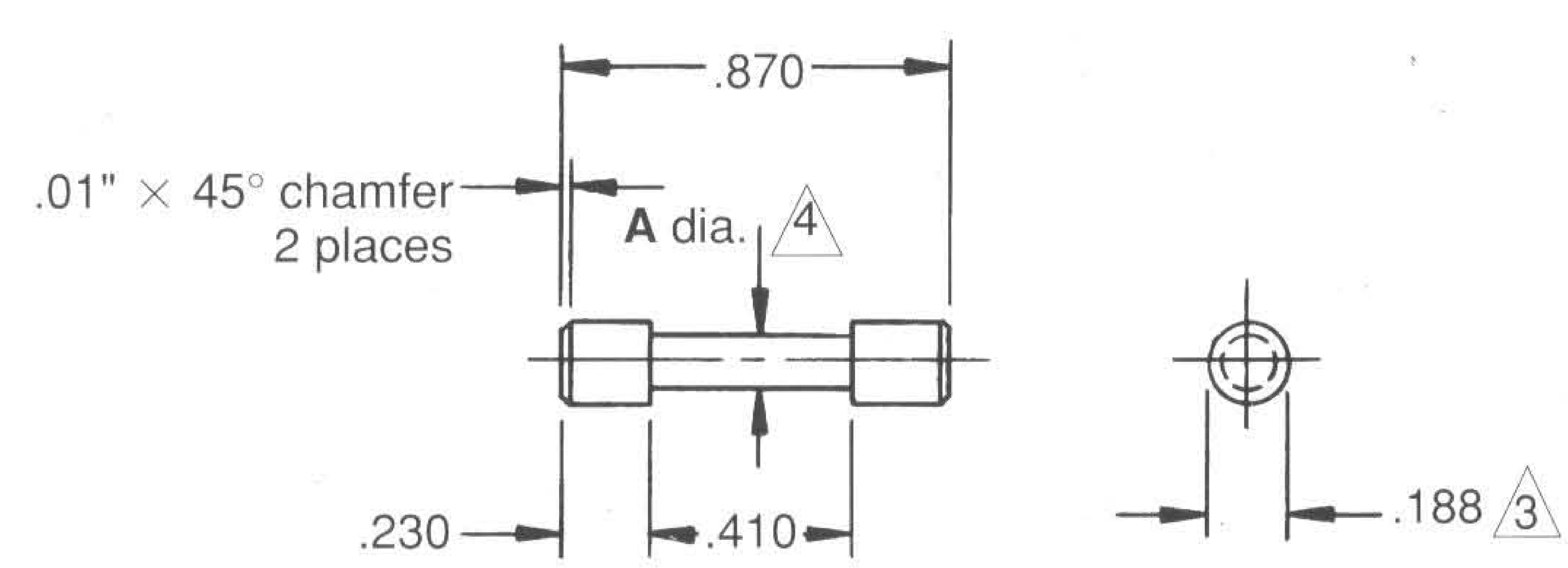
the receiver must place solid metal behind the striker sleeve bore in the breech block. If the firing pin ever ruptures a primer, the luckless shooter could lose an eye or worse. Please do not ignore this cardinal safety rule. Be smart and be safe.

The rifle builder also does not have to slavishly follow the stock design I favor. As can be seen from the picture, I happen to like "cheek piece" stocks with a "rollover" comb and made out of the fanciest figured walnut I can buy. And the prettiest figure on my stock and forearm doesn't even show. That's on the other side of the rifle. But if you like thumb hole stocks in myrtle wood or mesquite, have at it. There's nothing that says your rifle can't make a statement about you.

I said earlier that this article was about the construction of this action, as well as about the design. So, let's get on to construction, which is the interesting part. I recommend that you start your activity with the receiver. There's a good reason for this. The central feature of the receiver is the breech block slot. You will rough it out and finish-shape it, hopefully to the dimensions called for on the detail print. But the breech block must fit this slot with a snug, sliding fit having a clearance of maybe 0.001". I have found it is a lot easier to finish the outside contour of the breech block to a desired dimension, rather than having to produce inside dimensions on the receiver slot to the required small clearance. I found this out my way, which is, of course, the hard way.

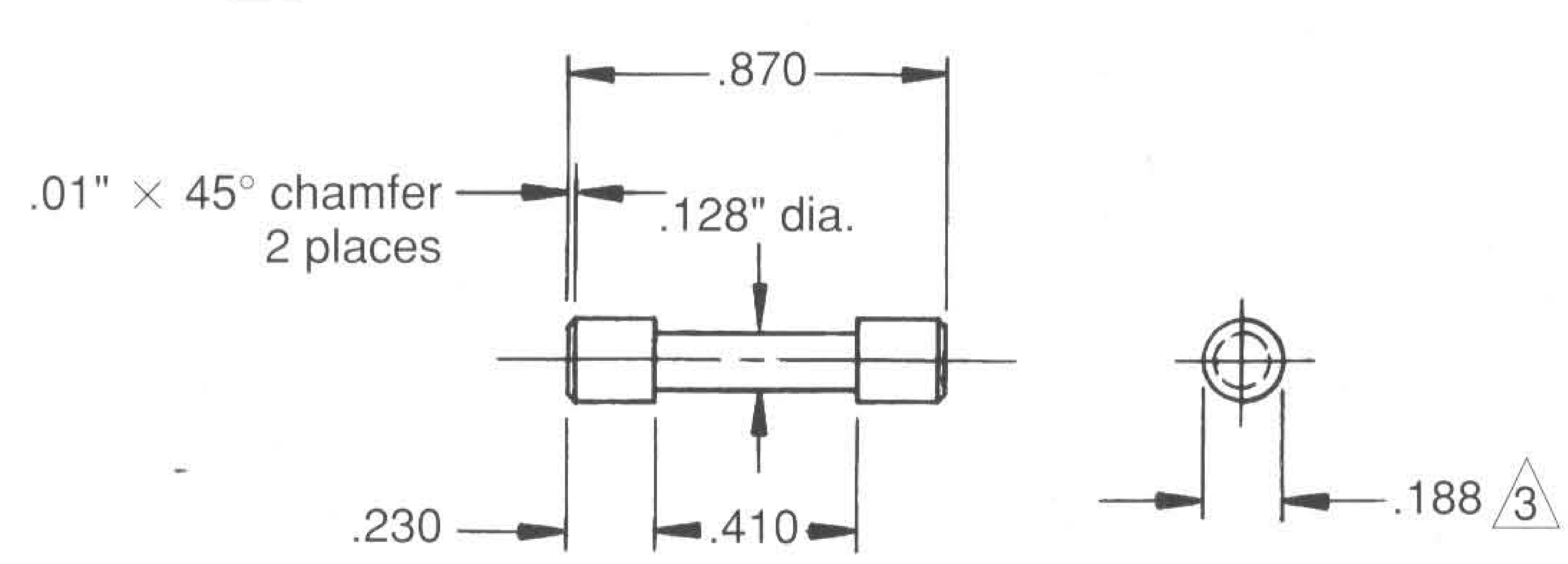
When I built my first receiver, I used *Swede-Oil* tool steel–a variety I had often used before. However, in forming the breech block slot, I didn't radius the corners for stress relief, as is now shown, because I didn't think I'd have a problem. After all, I had many blanking dies working, quite a few of them making parts having sharp corners, and none of these dies had ever cracked during hardening. But that first receiver did, leaving me with the problem of remaking the part and making it snugly fit the now hardened breech block. That's when I built the grinding head for my shaper (Photo 6). I had to have a way of working hardened steel. So, play it smart and learn from me and, hope-

1. Material: Type 0-1 tool steel.
2. Harden and draw to $R_C$ 52-55.
3. (3) 0.0002" slip fit to breech block.
4. (4) Dia. **A** to be adjusted to make breech block fit snugly against barrel face.




BREECH BLOCK CLOSE PIN
PART 12

1. Material: Type 0-1 tool steel.
2. Harden and draw to $R_C$ 52-55.
3. (3) 0.0005" slip fit to receiver.




BREECH BLOCK OPEN PIN
PART 13

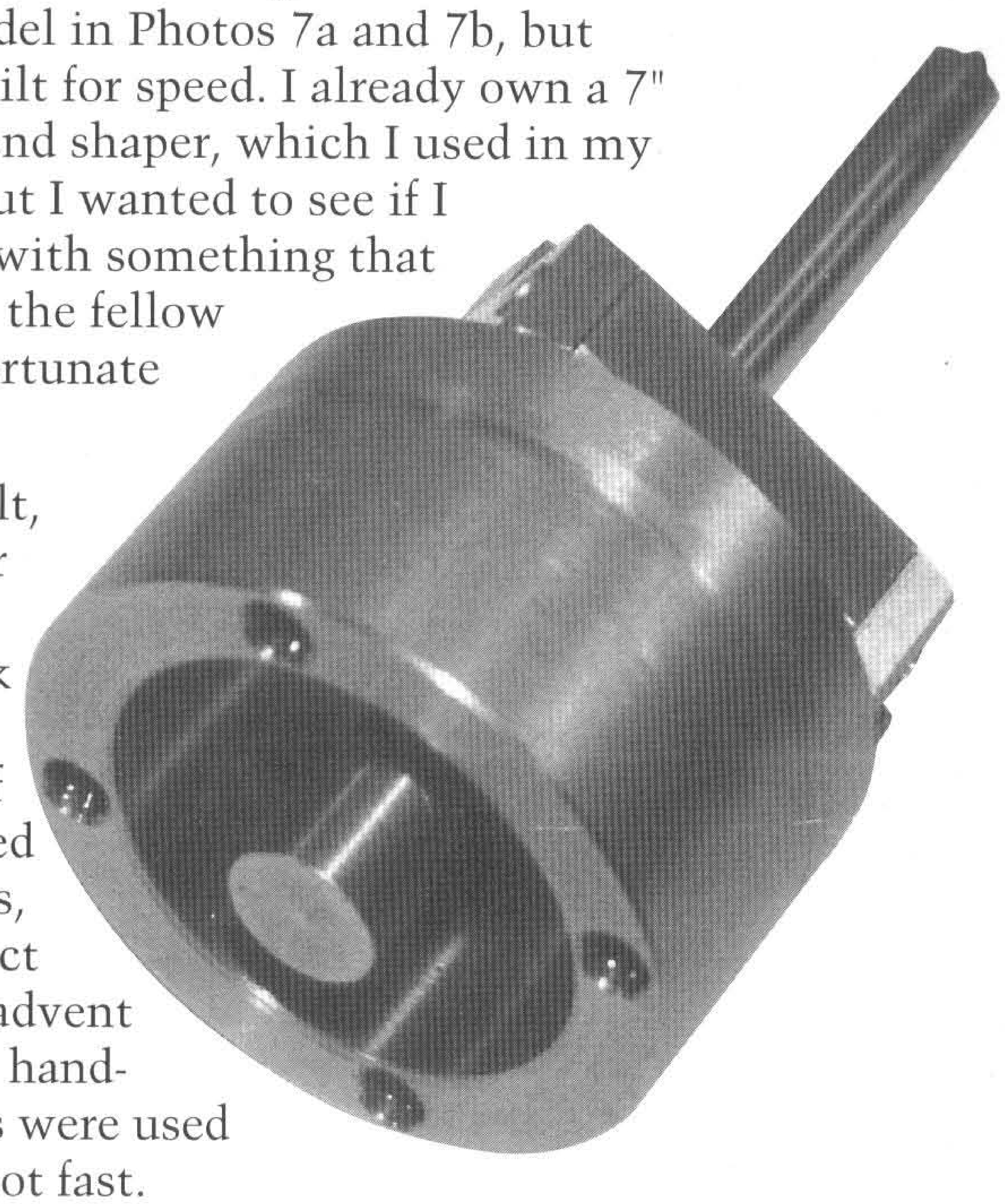
fully, you'll have fewer adventures than I did.

When I buy hot rolled SAE 4140, I can get it in a mill thickness of only 1-1/2". When I start to square up the block, I have to work that down to 1.293", which is a lot of chips. I leave a few thousandths of stock on a side for later finishing. However you do it, worry the block down to that thickness, taking fine finishing cuts to keep the surfaces as flat and parallel as you can. Having done that, you can now machine the bottom surface of the block to clean up, again taking a fine finishing cut to make sure the bottom of the block is as square to the sides of the block as you can make it.

When you are done, remount the block in the machine and take a cleanup cut on the top of the block in the area where the breech block slot is going to be cut. Now, change your setup to machine the end surface of the block. This is the end the barrel will screw into. I'd recommend an angle plate setup, with the receiver block in a upright position. Indicate the vertical surface of the angle plate to be "dead-nothing" (toolroom parlance for perfect) parallel to the vertical spindle travel, shimming the angle plate if necessary. Then, mount the receiver block on the angle plate, clamping lightly, and indicate the best side (side "A"), hopefully to again be dead-nothing parallel to the vertical spindle travel.

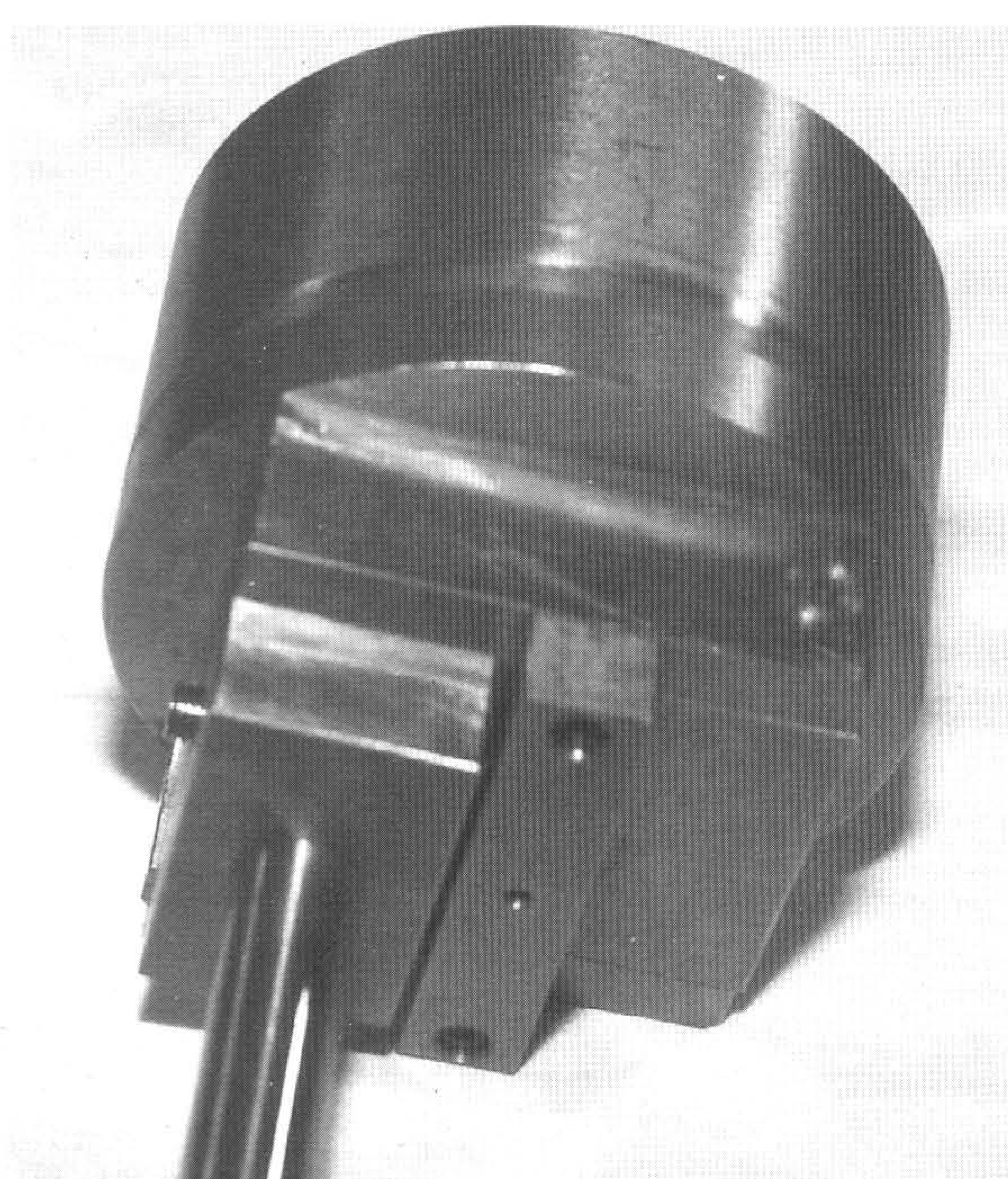
Clamp everything down tight and indicate again, to make sure nothing moved, and then take a cleanup cut on the top surface of the block. Take several light cuts if you have to, to make sure this surface is dead square to both the bottom and side surfaces of the block. After doing all these great things, you can remove the block from the machine and clean off all the chips and cutting oil. File-break the corners lightly to remove all burrs, and then get your can of layout blue. Mark the "A" and "B" sides of the block, as shown on the detail drawing. What you're doing here is marking the future locating surfaces, because as you do future machining operations, you want to always use the same location points. Also blue the top surface of the block where you have cleanup-machined the surface. Now lay out the outline of the breech block slot in the proper location and take a sharp prick punch and lightly punch along the slot outline every 3/16". Now lay the block carefully aside; other things await.

What you need now is a tool. This tool is an angle block, carefully crafted to have an included angle of 7° 20′ (Tool 1). It should take you only a couple of hours to make. Also note Tool 2. It's called a Shaper Tool (Sort Of). If you own a shaper already, ignore this tool. If you don't have a shaper, this is what you are going to have to build to finish the receiver breech block slot to its rectangular shape and requisite dimensions. I spent about eighteen hours making the model in Photos 7a and 7b, but then I'm not built for speed. I already own a 7" stroke South Bend shaper, which I used in my construction, but I wanted to see if I could come up with something that would work for the fellow who is not as fortunate as I.

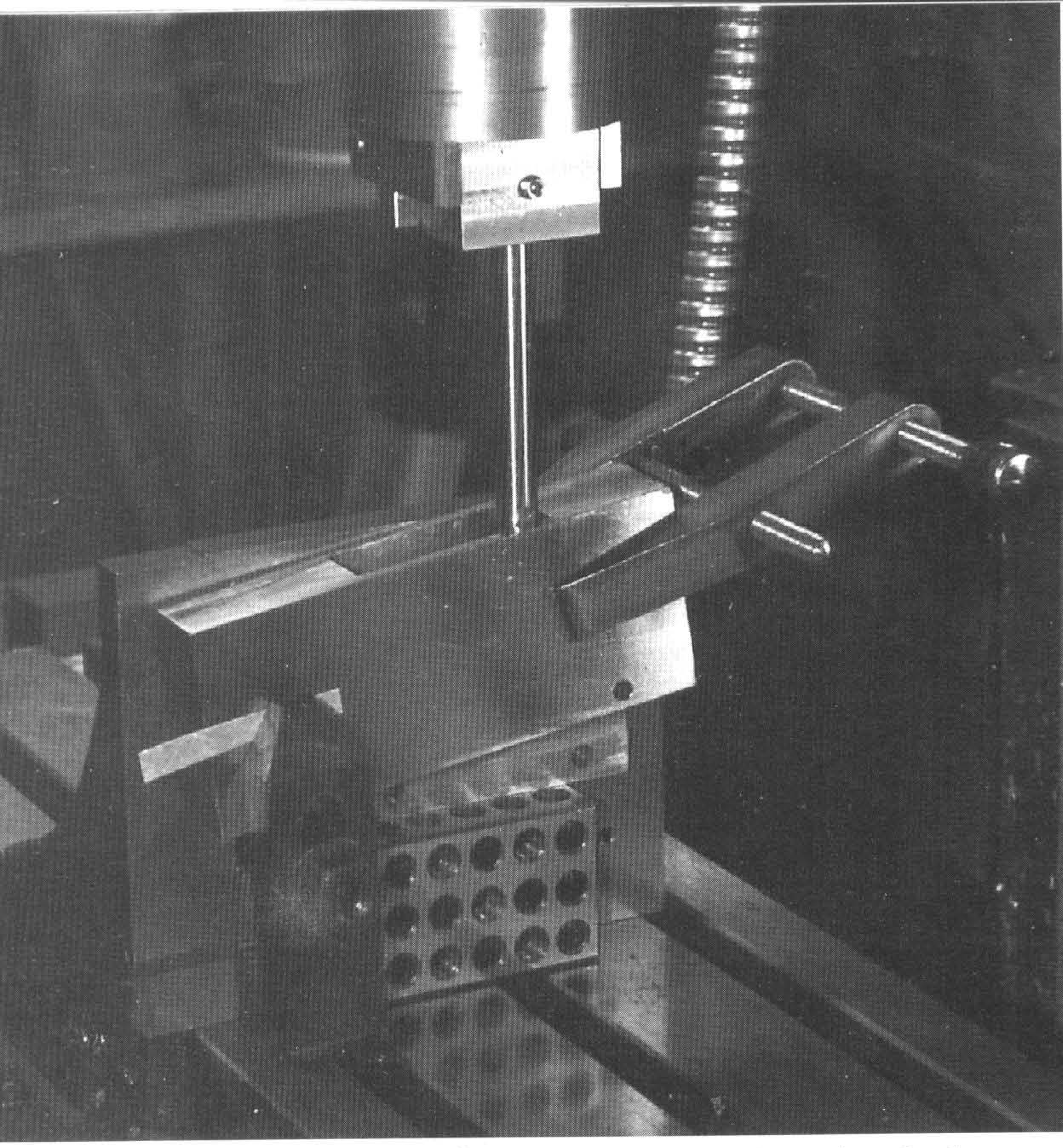


**7a** ***The Shaper Tool (Sort Of) is designed for hobbyists who need a shaper but don't have one (see photo below also).***

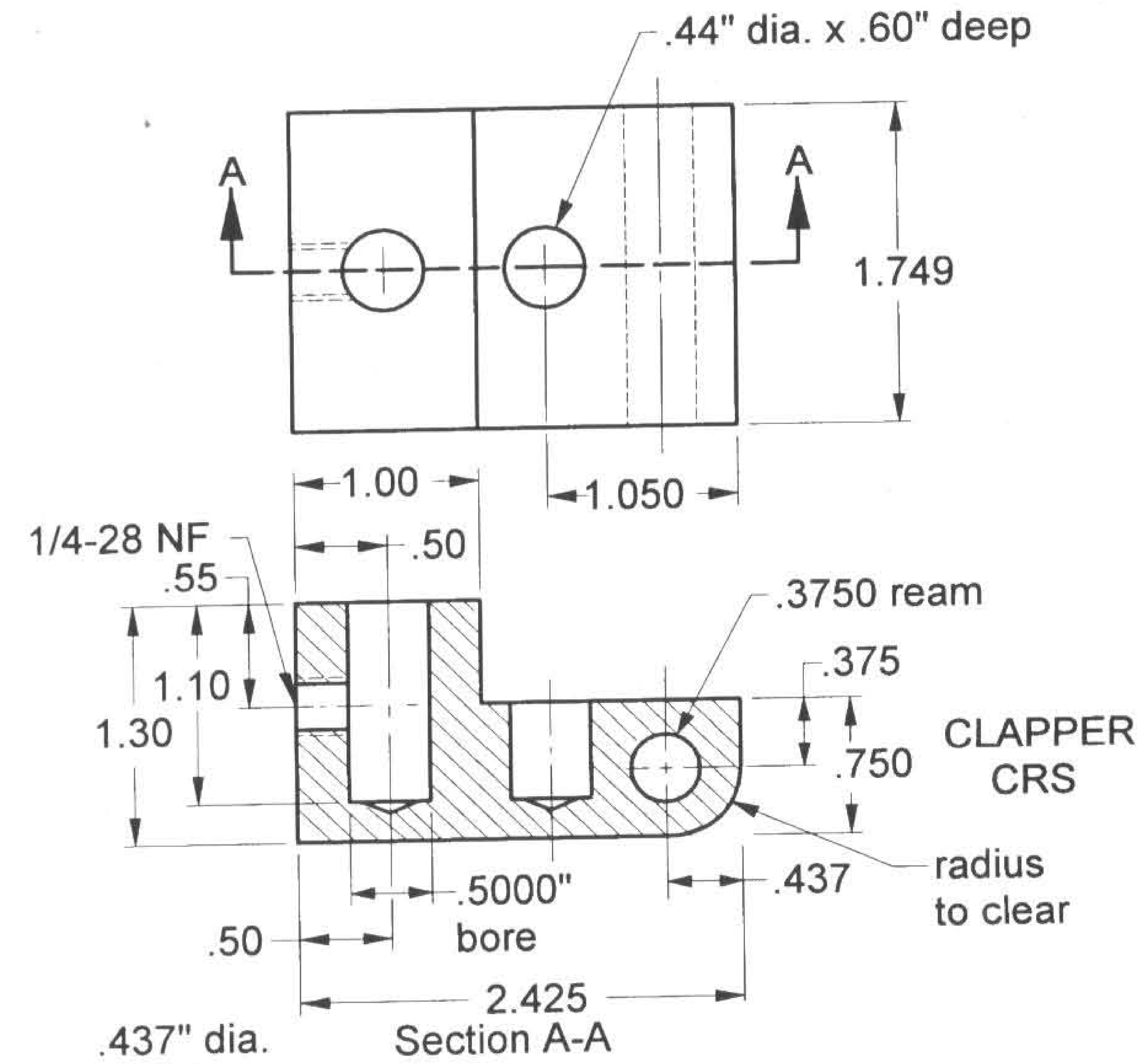
This is the result, and believe it or not, it does work. And work it is to use it, but that's life. If you feel bummed out by all of this, reflect on the fact that before the advent of steam power, hand-powered shapers were used by all. It's also not fast. If you want fast, the only way to get it is to work up a sweat. I find that a 0.007/0.008" depth of cut with about a 0.003" feed per stroke works pretty well. It's set up in my Enco model No. 1526 vertical mill (Photo 8), but any mill/drill should work. With a

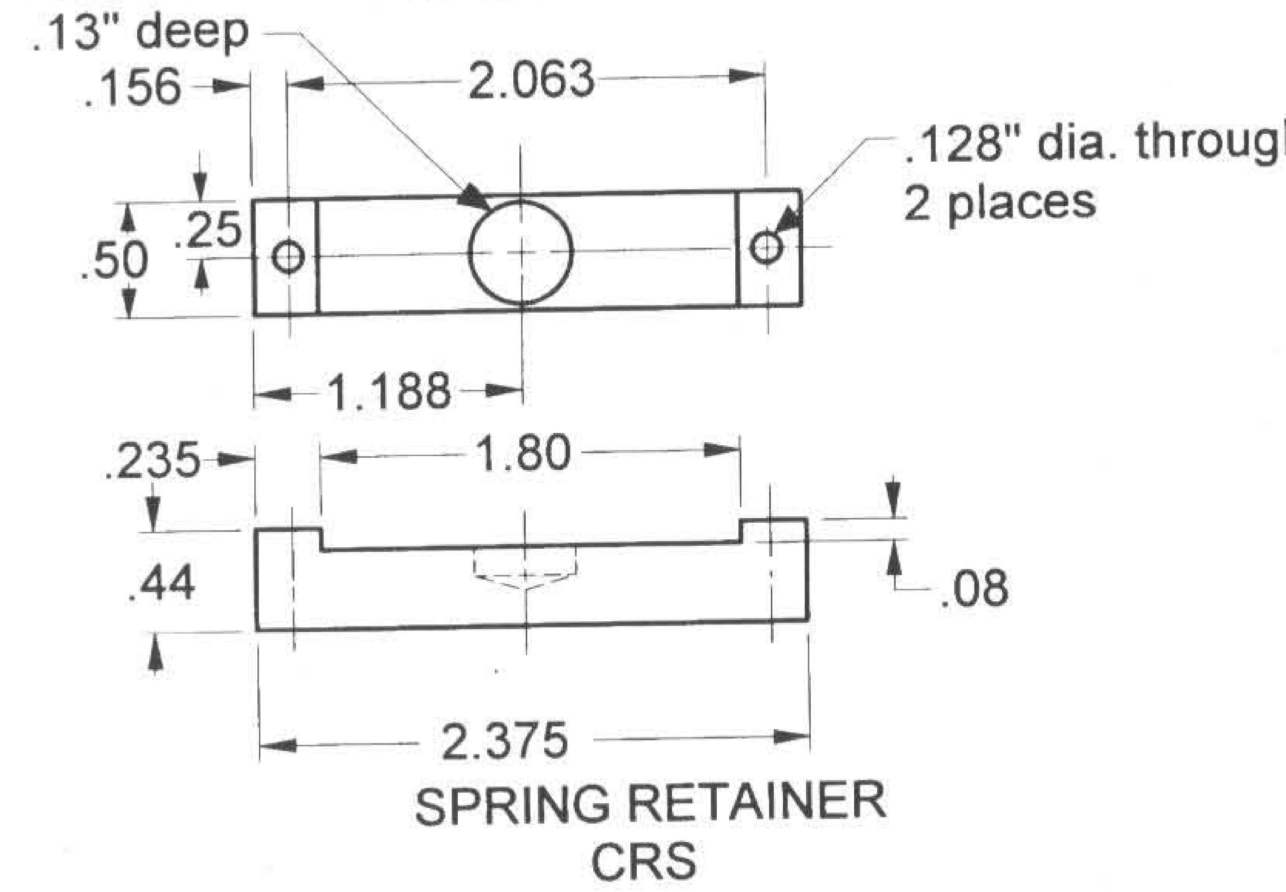


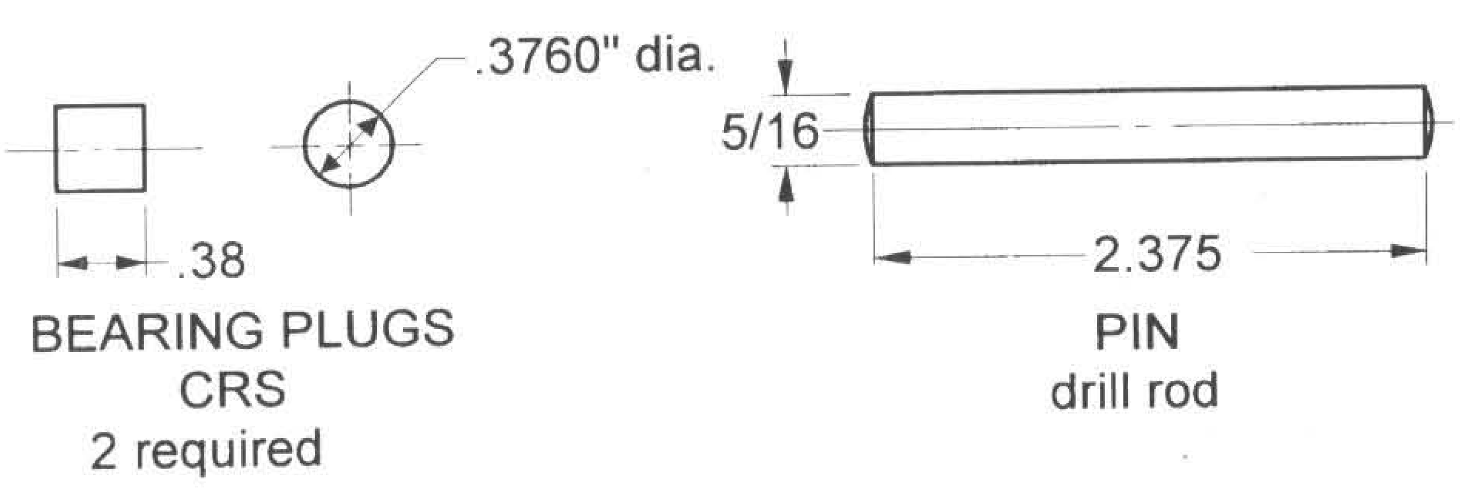
**7b**

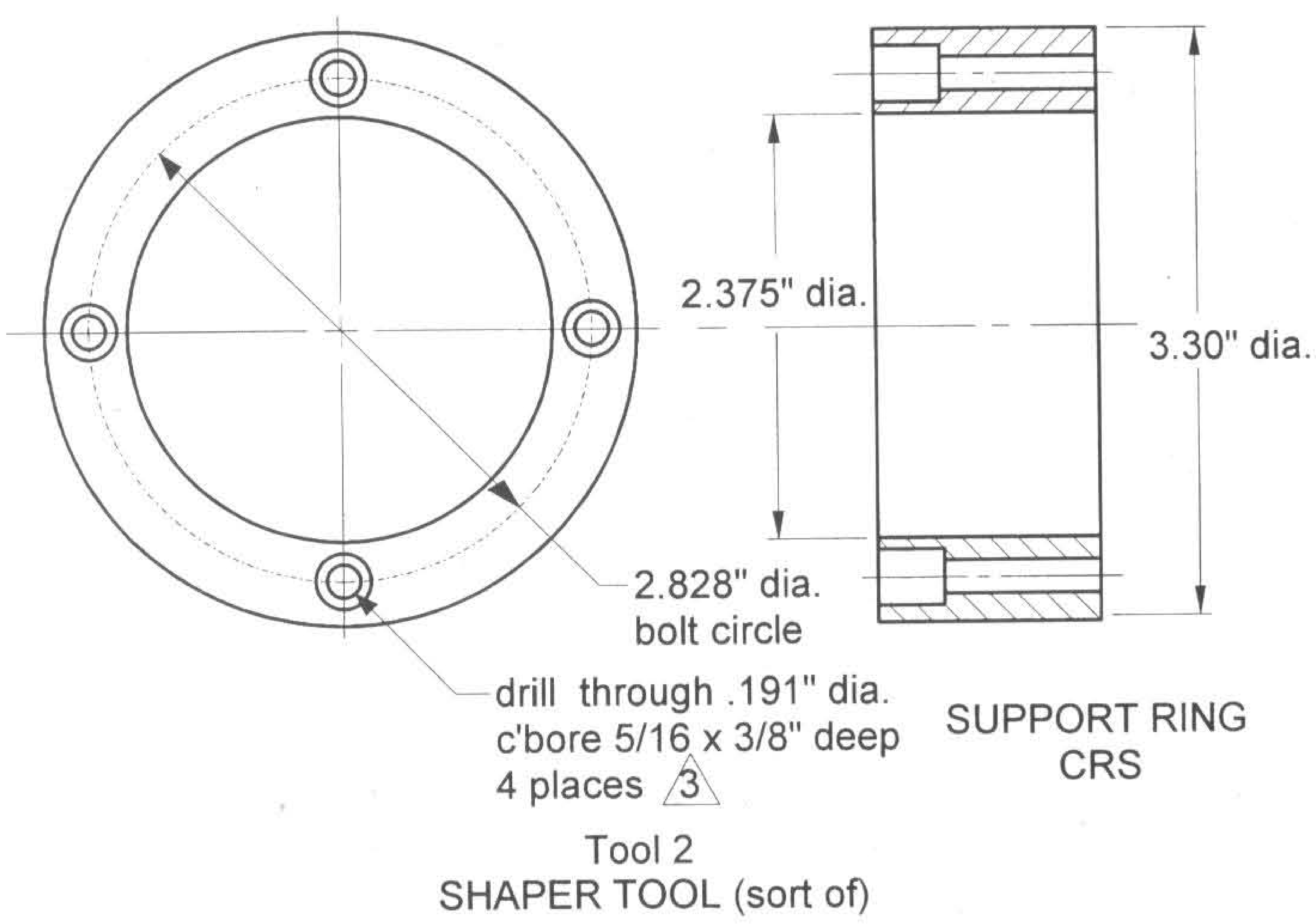


**8** *The shaper tool is shown here in the sort of setup needed to finish the receiver slot.*



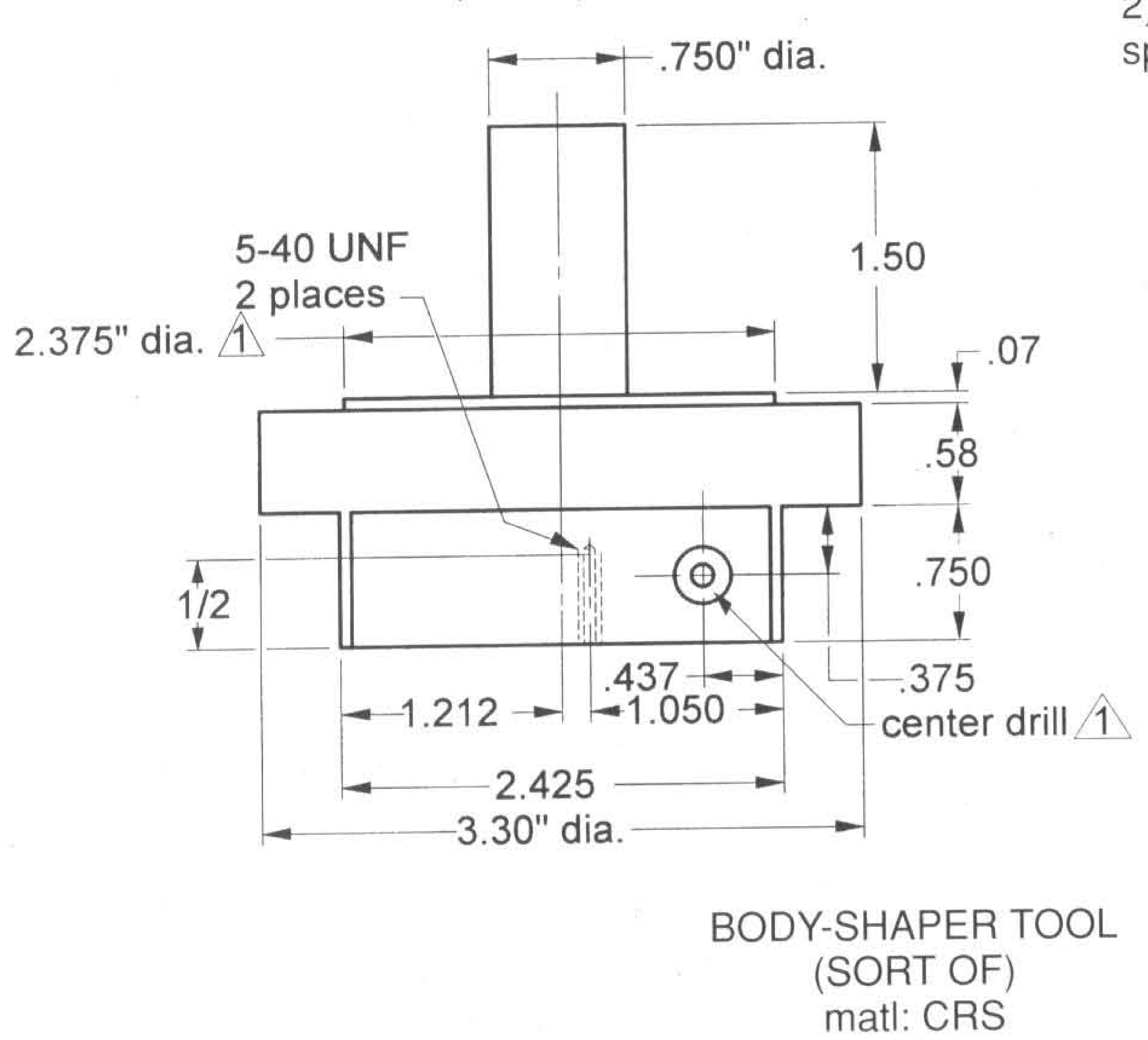



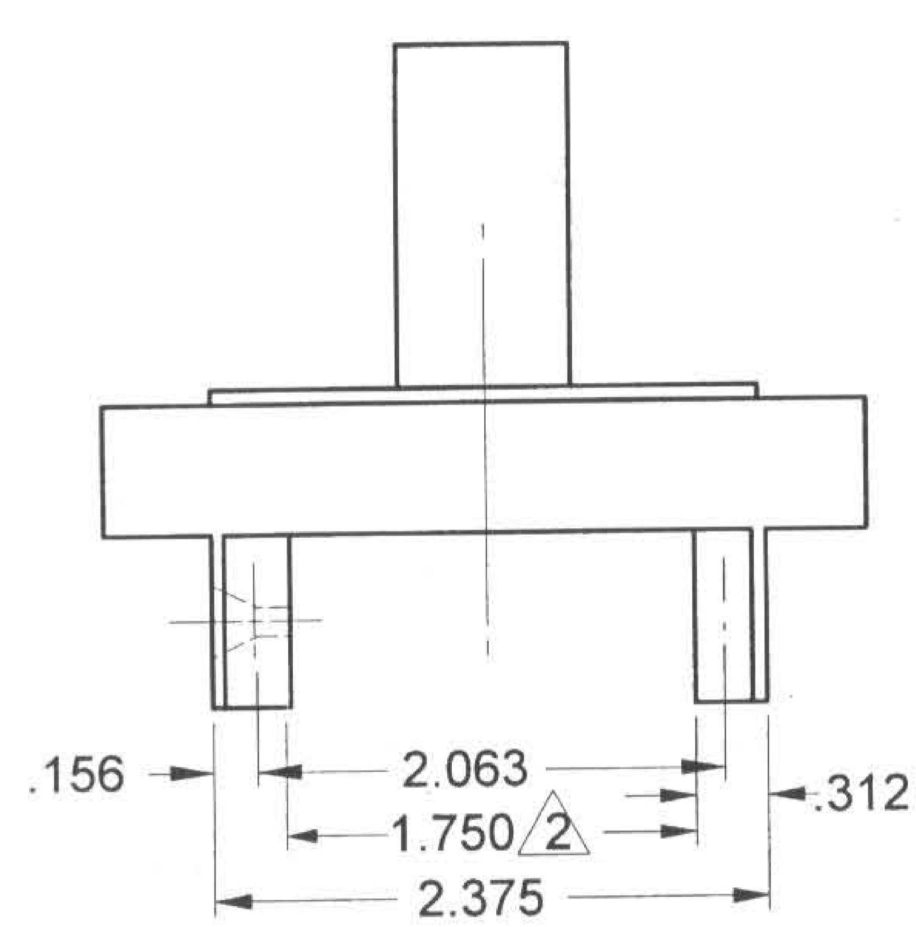




**CONSTRUCTION DETAIL FOR SHAPER TOOL:**

1) With a heavy press fit, insert the two bearing plugs in the clapper. Clamp the clapper to the tool body. Drill 3/16" diameter through the clapper and the body, using the center drill spotted in the body as your guide. Drill the 3/16" diameter hole to letter N (.302") diameter. Ream it to the .3125" diameter, and insert the pin.

2) Mount a heavy spring (10" long) to the clapper. Put the spring retainer in place, and hold with two 5-40 NF screws.




3 X-FER punch pattern to body: drill and tap 10-32 NC (4 places) x 1/2" deep in the body.

2 Drill and ream at assembly.

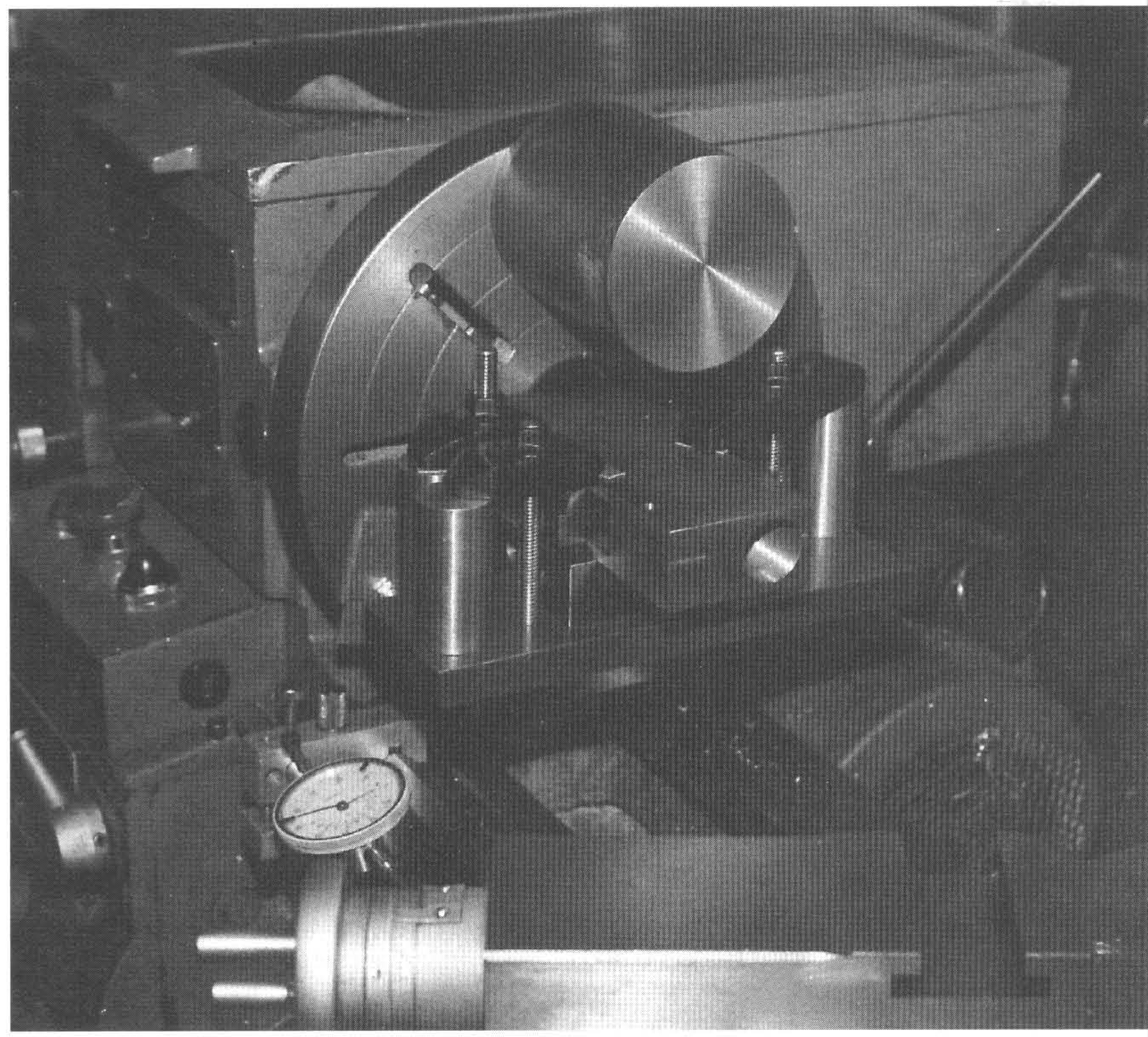
1 Light press fit to the support ring.

little tailoring, it might work in a lathe also, but I haven't tried that.

Anyway, after all that talking and toolmaking, you are finally ready to put the receiver slot in your carefully prepared block. Make the angle plate setup, indicating everything to make sure it's square and set up at the proper tilt angle. Tighten down the whole lashup so nothing can move and then proceed to run a 3/4" diameter hole all the way through the block. End mill a flat starting surface for the drill, keeping the center drill location centered in the slot and about 13/32" from the front end slot layout line.

Start through with a 5/16" diameter drill first and enlarge the hole with successively larger drills until you are up to the required 3/4" diameter. Then change the 3/4" drill for a 3/4" diameter, four-flute end mill, extra long, with a 3" cutting edge. Move down the slot 0.050" and run the end mill through the block, elongating the starting hole. Retract the end mill, move 0.050" further down the slot and repeat the machining cut. Keep moving and machining and in short order you will be nearing the end point of the roughing operation. When you are done, you are at the point of trying out your shaper tool (sort of).

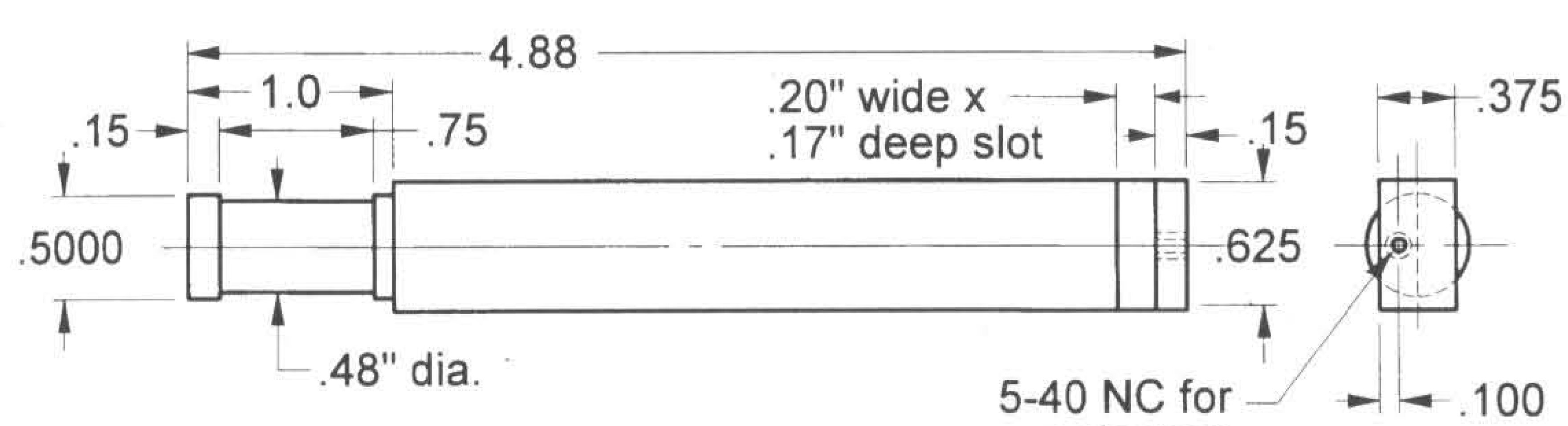
Keep the same setup you used in the roughing operation; just install the shaper tool. Using my tool, I do not have to lock the spindle to keep it from moving. When I tighten the 3/4" collet, the draw-in tendency of the collet snugs the support ring on the tool up tight against the nose of the quill, and the spindle



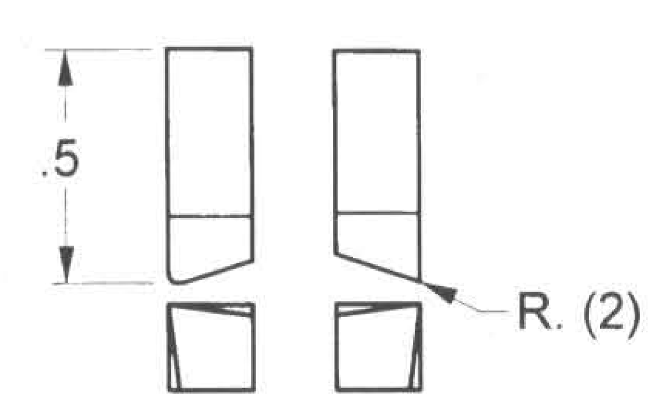
**9** ***The setup in the lathe for putting the barrel bore and threads into the end of the receiver block.***

doesn't turn. If your machine doesn't react like that, you may have to make a clamp ring to anchor the shaper tool to the quill OD. Anyway, you're all set up, so get the tool in contact with the work and try things out. As I said before, maybe 0.007" depth of cut with 0.003" traverse per stroke seems to work.

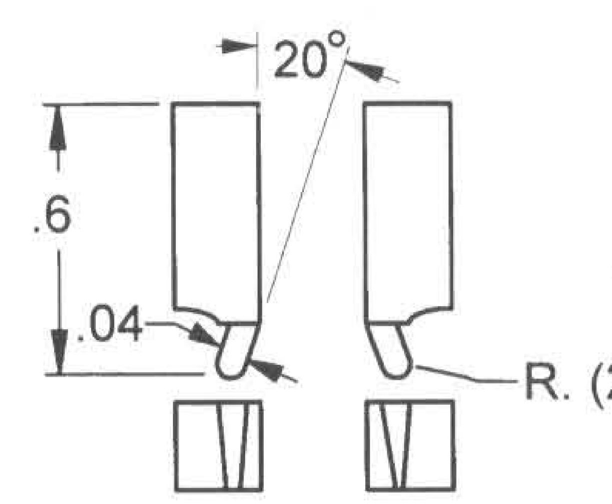
Start by cleaning out the rounded corners of the rough-cut slot. When they are squared out,



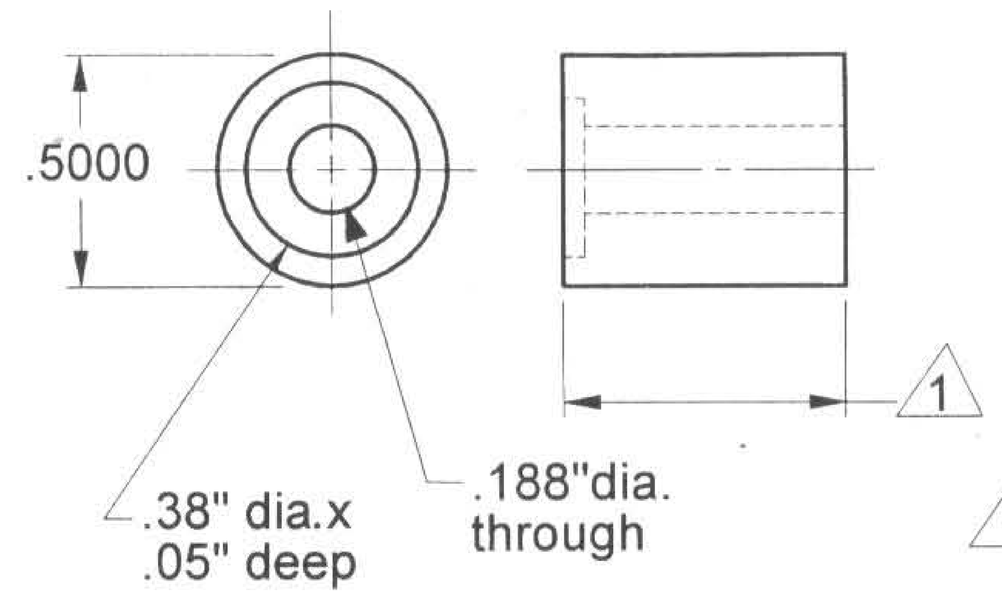

EXTENSION TOOL HOLDER
CRS




RH and LH cutting
tools, 3/16" square

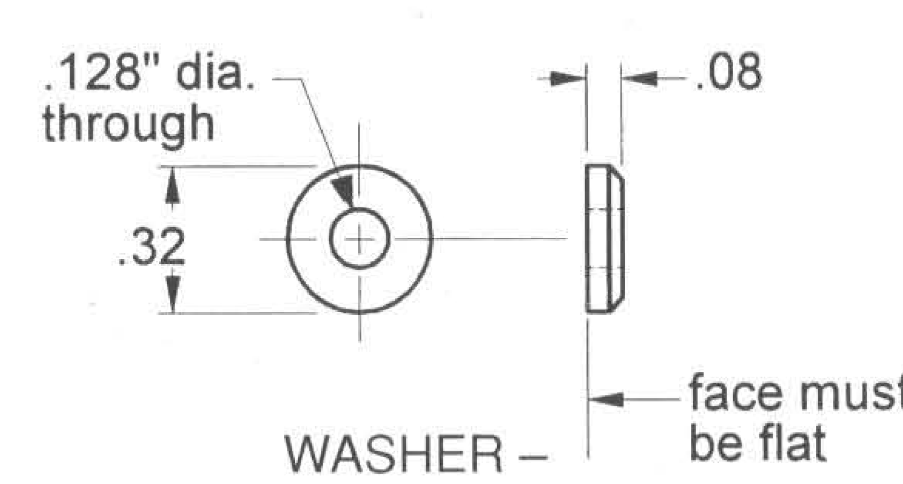



RH and LH relieving
tools, 3/16" square



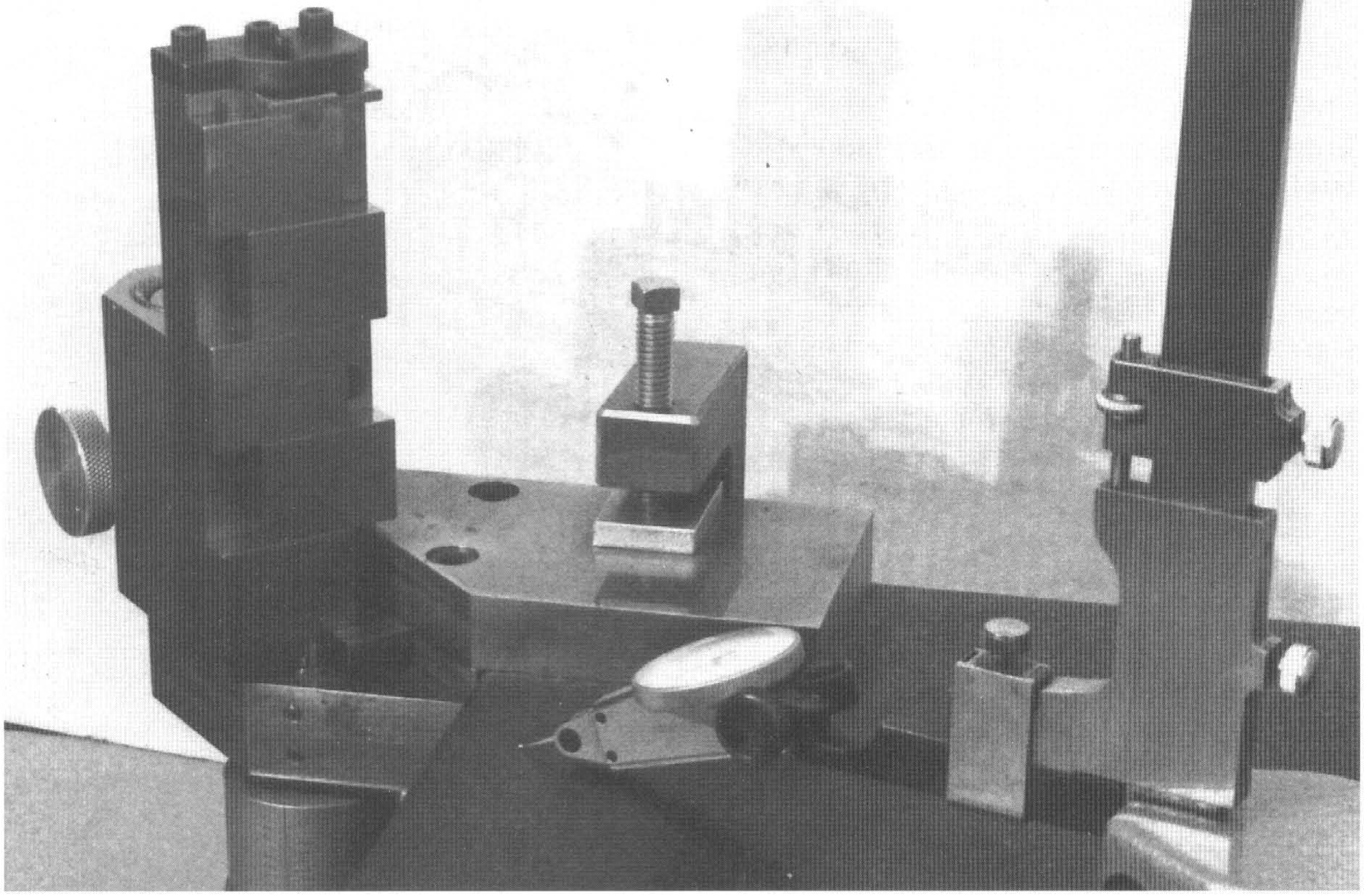

Tool 3
TOOLMAKER'S BUTTON
drill rod

1 Buttons are usually made in sets of four. Three buttons are .500" long. One button is .625" long.




WASHER –
TOOLMAKER'S BUTTON
drill rod

The button and collar are used with 5-40 UNF socket head cap screws, 3/4" and 1" long.



**10** ***The author's Vernier height gage being zeroed to guarantee accurate measurements with his 0.0001" reading, micrometer height gage.***

it's relatively simple to work your way down the sides and ends of the slot. You'll have to change your tool point orientation quite often, but you have to do that with a regular shaper, too. It's a slow operation, with either a regular shaper or with the hand tool, so don't get discouraged or try to speed things up by increasing the depth of cut or the chip thickness. It simply will not work to your advantage. Patience is the watchword here; probably shortened work sessions are a good idea, and you'll need plenty of rest breaks.

After finishing the shaping of the breech block slot, you are probably in the mood for a different kind of machining job. What I'd recommend next is the spotting and drilling of the 0.2501" diameter holes in the bottom front of the receiver block. This is a sneaky operation to do right, but you can lick it if you use the smart strategy. What happens if you try to drill the holes all the way through from one side is that the drill wanders off axis. I have seen that happen often enough, with the drill moving as much as 0.007". So, what you should do is center drill at the proper location, but from both sides of the block. If you are careful in the use of your edge finder, you can spot the center drill within 0.0005" of exact location on both sides of the block. When you have done that, drill a C-drill (0.242" diameter) hole about 1/2" deep on both locations. You will ream the hole later after finishing the rectangular hole in the barrel face.

Now is the time to go after that rectangular hole in the barrel face surface we had just mentioned. The block is placed in the vertical position in the same kind of angle plate setup used to rough and finish the breech block slot. Here, of course, there is no angle block in the setup. Blue the surface and lay out the outline of the opening, lightly punching the outline as before. Mount the block on the angle plate and indicate the "A" surface to be dead parallel to the vertical spindle. Clamp the whole thing down tightly, again making sure nothing has moved.

Center drill for a 3/8" diameter starting hole in one corner of the rectangle, keeping the hole OD about 1/32" away from the periphery of the rectangle. Drill the 3/8" clearance hole through and then change the drill for a 3/8" diameter, four-flute end mill having 2-1/2" long flutes. Then, as with the breech block slot, move the end mill 0.030" off the clearance hole and plunge mill through, to elongate the clearance hole. Move the end mill as before and repeat the cut, continuing until the rectangular opening has been roughed out. There's no need to tell you what to do now. Just change the end mill for the shaper tool (sort of) and get to work. By this time, you're probably getting so good at the whole routine that you'll be done before you know it. In finishing the opening, try to hold the 0.150" lower wall thickness to 0.153", to keep a little stock on surface "B" for final finishing. Also make every effort to keep the rectangular hole centered with respect to the center line of the receiver, keeping the side wall thicknesses as nearly identical as

possible. Now is a good time to finish ream those two 0.2501" diameter holes. Do it from both sides, just as you drilled the holes.

Are you in the mood to make an outlandish looking setup? If you are, this is a great time to put the barrel bore and threads into the end of the receiver block. This is going to be done in the lathe, on a faceplate setup. I hope you have an angle plate that is finish machined all over. That simplifies things. Even if you do, it is still a setup I feel I should apologize for. It looks as if I have taken a trash bin full of junk and hung it all on a faceplate, which is getting close to the truth. But that's the way this setup must be.

The first order of business in this operation is to get a setup that can't help but work. First of all, though, is the job of determining where the barrel bore should be located. Get out your trusty can of layout blue and blue the machined end surface. Then, measure up from surface "B" a distance of 1.790" (a scale measurement is okay here), and make a scribe mark. Then, likewise, find the center line of the block and scribe its location. Prick punch the location lightly and measure the coordinates to make sure they are what you want. If you have to move the punch mark, do it and then center punch for drilling. Drill a No. 38 (0.1015" diameter) hole 1/2" deep and tap 5-40 NF by 3/8" deep.

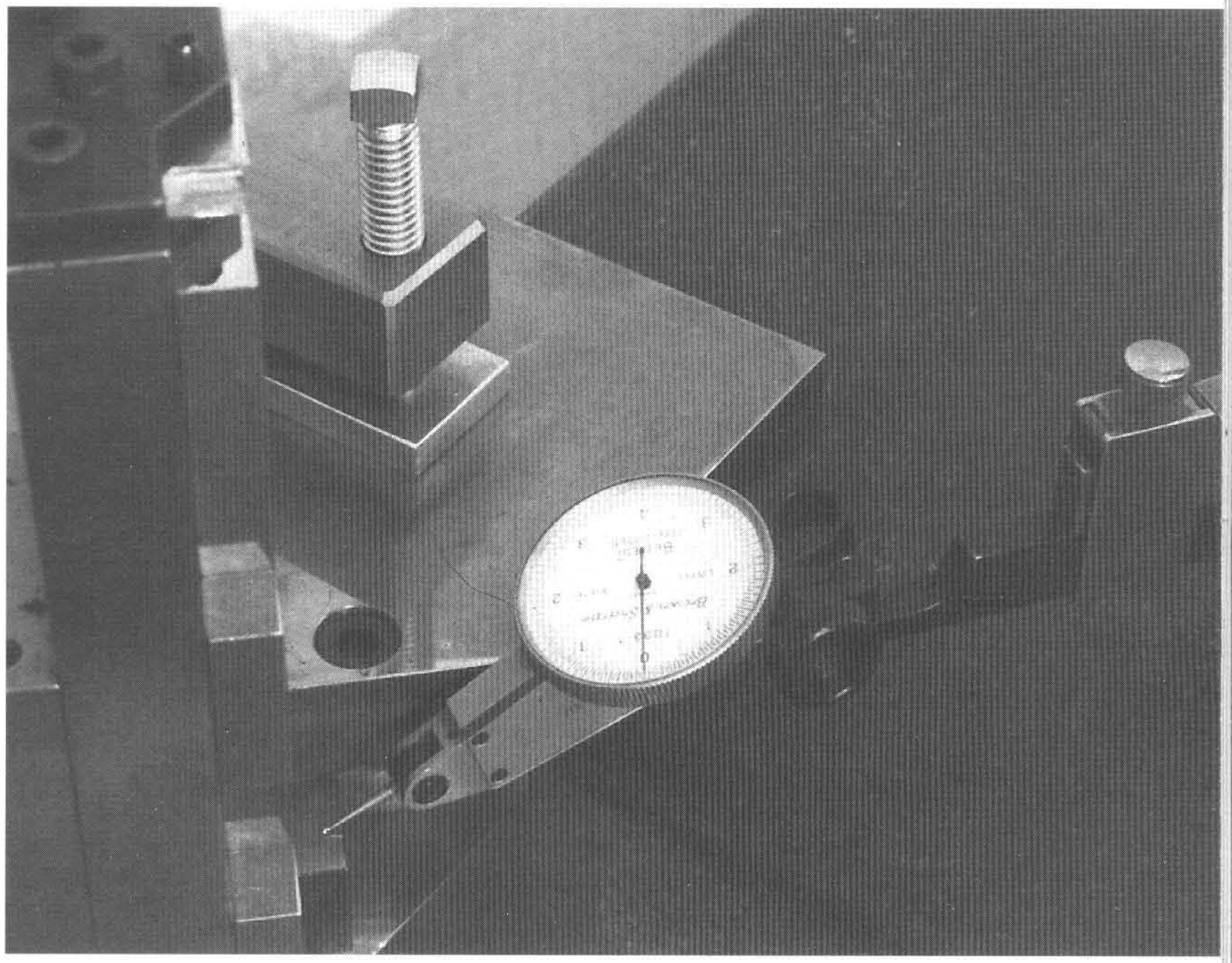
Now you need a toolmaker's button. If you don't have a set, now is a good time to make one (Tool 3). They are easy to make and they are handy to have, being the poor man's jig borer. Mount one of the buttons on the front face in the 5-40 threaded hole you just made. Tighten it down only lightly, as it is to be bumped into its exact location before being locked down. Since the toolmaker's button is 0.5000" diameter (exactly, we hope), get your depth mike and measure up from face "B" to the button. If the distance is not 1.543", bump the button until you get the dimension. Then measure the distance from side "A" to the button. You should get 0.3965" for the dimension. Of course, you won't get 0.3965", so you'll have to bump the button to get it.

After going back and forth like this many times, you'll appreciate the why of the jig borer. But stick with it. Sooner or later, everyone gets lucky and you'll get to tighten the button hold-down screw, hoping the button doesn't move when you tighten the screw. If it does, stick your head into the freezer until you've cooled off and try it again. You'll get it right this time, sure.

The angle plate is hung on the faceplate in a fairly precarious fashion, so let's make a rule. Use only 3/16" NC bolts or bigger, if you have the room, and tighten them down really tight. I used a 4 × 4 × 4" angle plate. This size is not necessarily a thing of choice. I would prefer a slightly larger angle plate, but it is a very accurately made tool, being finish ground. I have another larger, machined-only model, but for accuracy the smaller one is best. Use the most accurate tool you can get. It saves much setup time in trying to get dead-nothing indicator readings if you don't have to fiddle around with a lot of shims.

The largest problem of this setup is to get dead-nothing indicator readings from the "A" and "B" surfaces and the toolmaker's button on the front face. Take your time in bumping the workpiece into the proper position and then lock it down, tightly. This is no time to have a workpiece move during machining. You'll also find it's an excellent idea to counterbalance the faceplate setup at this point. When you are drilling and boring the barrel thread diameter, you have to run the lathe at moderate speeds. If your setup is too unbalanced, your lathe will vibrate excessively, a condition that cannot be tolerated.

You can now remove the toolmaker's button, and center drill again to make sure your bore will start off in the proper location. Run a 3/8" diameter drill through first and then open the hole up with successively larger drills, up to about 7/8" diameter. Then switch to a 3/4"



**11** ***The author's surface plate measuring tool was built to guarantee accurate measurement on machined parts.***

diameter boring bar and finish bore the hole to 1.008" diameter, which is the minor diameter of the 1.062-24 UNEF thread. Now, switch the boring bar setup to cut the internal threads. Use the same boring bar for rigidity, but put a thread cutting tool in place and fishtail gage it to the correct angular cutting position. Get your lathe geared up to cut 24 tpi and get into your lowest back-geared spindle speed.

Check your threading dial plate to make sure you know when you can close the half nuts, and then start cutting threads. I usually rough cut the threads to within maybe 0.002" of correct pitch diameter, which means I feed the top slide (set at an angle of 29-1/2°) out 0.034" and then I stop. I finish the threads using a 1.062-24 tap to clean up and deburr the threads. At this point, the tap will usually start about one turn, so I start it and then support the outboard end using a live center in the tailstock. Now, it's no problem to turn the tap through the threads, giving a finished, properly sized thread. This is important, since it is impossible to measure the pitch diameter of an internal thread without having "go" and "no go" thread plugs, which people like us do not often possess. You can tear your setup down, because for now, you are finished machining your receiver. When the chips and oil are cleaned off the block, a little judicious use of a fine flat file is in order to get rid of burrs and to smooth the surfaces of the breech block and extractor guide openings.

Now, you have the job of deciding exactly what size the breech block slot is. This is not a trivial task. Since the geometry of the hole is very important, it would be great if you could assume the slot is truly rectangular. But things are never simple, at least for me. What you need now is a surface plate of some sort and an indicator with a long point, mounted on some kind of height gage. What lengths folks will go to is illustrated in Photos 10 and 11, which I blush to say is the height gage I built, so I can find out just how accurately I did my job. It reads repetitively to 0.0001" and tells me accurately what my slot geometry really is. But don't have a cardiac arrest! I don't propose that you should take three months off and build the pictured gizmo. Do the best you can with what you have. I didn't have my height gage when I built my first action, either.

Now, it's time to tackle the breech block. I presume you have decided what size your breech block slot is, by now. The job at hand, then, is to worry a block of No. 4140 down to those outside dimensions. I'm going to presume you hit the design dimensions of 2.475 × 0.875" right on the nose (safe assumption, right?). Try fitting the breech block into the slot. I dearly hope it will slide through for you with a nice, firm push fit. I suspect, however, that is not the case. Now comes your first educational experience of fitting mating gun parts together.

I always find it necessary to blue the receiver slot and the breech block. Shove the parts back together and find out where they interfere. Get your fine flat file out and try to work the problem out. Measure and blue; fit and file, shove and cuss. Eventually, you will find, the stubborn things will slide together and you will rejoice. Now you can get on to the job of machining some of the details of the block. Start first by using the 7° 20' wedge block to tilt the block to the proper angle to machine the bottom surface of the block.

In much of the machining instruction that follows, it will be necessary to drill holes in surfaces that are not perpendicular to the axis of the milling or drilling spindle. This can be successfully accomplished, keeping the drill point from wandering off the intended location, if the following practice is followed.

If, for instance, a 1/4" diameter hole must be drilled in a surface that is not perpendicular to the axis of the drill, first set an edgefinder in the toolholder of the machine and locate the workpiece under the spindle at its intended location. Then replace the edgefinder with a 1/4" diameter end mill, and mill a full 1/4" diameter flat on the sloping surface of the workpiece, at the intended location of the 1/4" diameter hole. Now replace the end mill with a suitably sized center drill, and without moving the machine table off its intended location, center drill a starting hole for the 1/4" diameter drill that is to follow, to machine the hole to its finished size, exactly on its intended location. This procedure must be followed in drilling a hole of any size, at an accurately spotted location, on any workpiece surface that is not perpendicular to the machine spindle.

Next, locate the four 0.188" diameter holes. The first two are the cross holes that accept parts No. 12 and 13. Locate and center drill each of these holes from each side of the block, using your edge finder very carefully. Then drill a No. 15 (0.180" diameter) hole at each location, to 3/8" depth. Next, find the two 0.188" diameter holes located in the front and

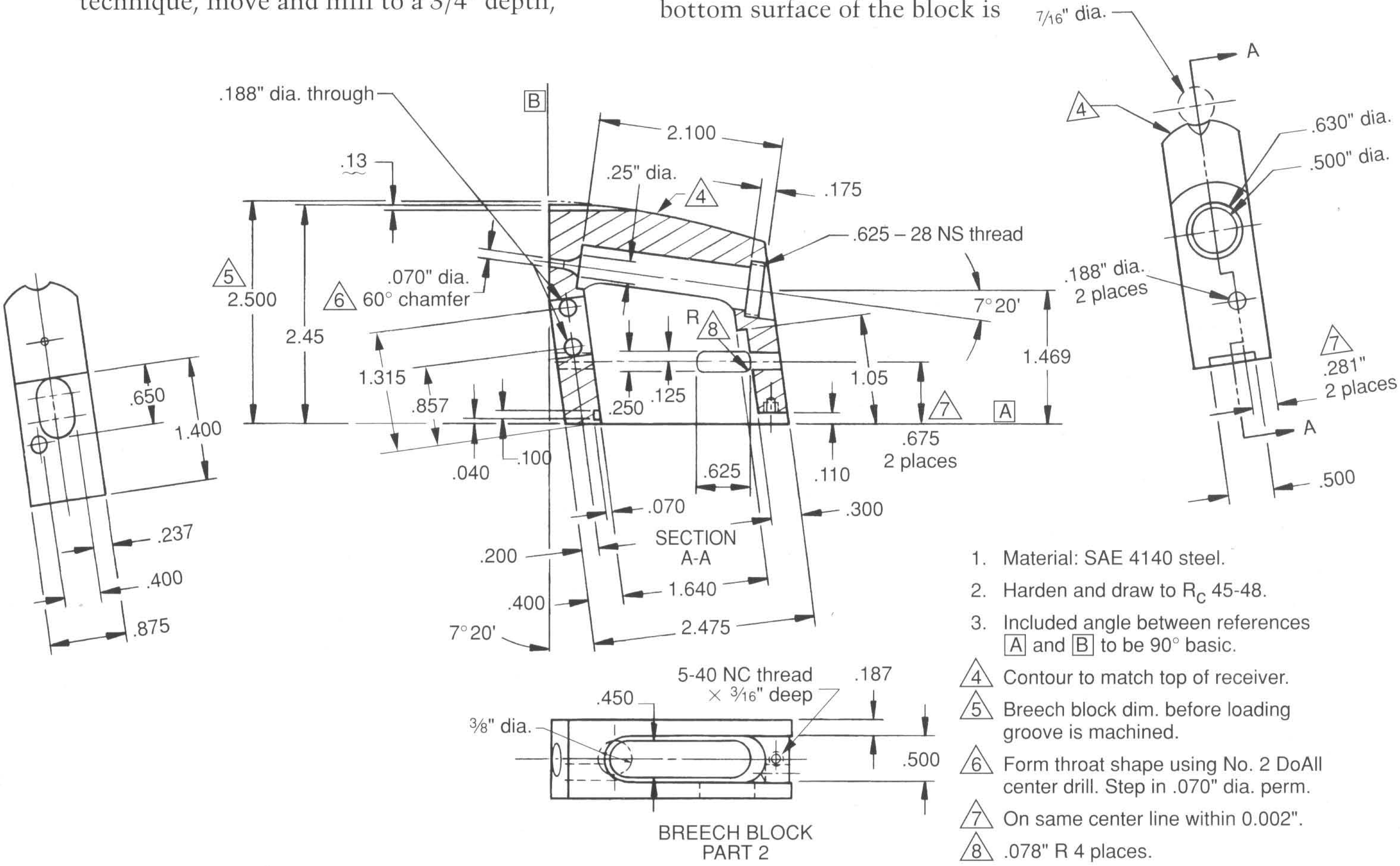
rear surfaces of the block. These holes accept the safety slide rod (Part 26). Using your edge finder, again, very carefully locate and center drill, recalling that the 0.675" height location should be 0.678" to allow for the finishing stock left on the bottom surface of the receiver block. After center drilling, drill a No. 15 (0.180" diameter) hole in each location to a depth of 5/8". Now, set up the breech block at the 7° 20' angle orientation, to allow the drilling of the 0.500" diameter striker sleeve bore.

Use an edge finder to determine height and center line locations, again remembering that the 1.469" dimension must be 1.472" to allow for finishing. Drill a 5/16" diameter hole to 2-1/8" depth and then follow up with a 1/2" diameter drill to the 2.100" depth. Finally, drill the hole to clean up using a 1/2" diameter flat bottom drill. Now is a good time to mill the oval-shaped slot in the front surface of the breech block. Set up, locating against the rear surface of the block, and using the edge finder, pick up the block center line and a dimension of 1.0" from the bottom of the block. Center drill here and then drill a 3/8" diameter hole to a depth of 3/4".

Now, change the 3/8" drill to a 3/8" diameter, two-flute end mill. Using the plunge-milling technique, move and mill to a 3/4" depth, holding the 1.400" and 0.650" dimensions. Finally, widen the oval slot to 0.400" width.

The next operation involves the milling of the large internal cavity in the block. Set the block in the mill vise, bottom side up, and with the block tilted at the proper 7° 20' angle. Using an edge finder, locate the center line of the block and a point that is 0.618" from the front surface of the block. Center drill at this location and follow up with a 5/16" diameter drilled hole through into the striker sleeve bore. Enlarge the 5/16" diameter hole to 7/16" diameter, and then change the drill to a 7/16" diameter, four-flute, extra long end mill. Using the plunge mill and move technique, machine the 1.640" length of the slot, making sure the end mill depth is controlled in the last half of the slot, so as not to mar the 0.500" diameter striker sleeve bore.

Using light cuts, widen the slot to 0.450", keeping the slot symmetrical to the center line. Keeping the same machine setup, change cutting tools to a 1/2" diameter, four-flute end mill that is slightly undersized. Starting at the rear of the slot, plunge mill to a depth of 1.05". Then widen the slot out to 0.500", keeping the slot symmetrical to the center line of the block. Finally, change the setup so the bottom surface of the block is



indicated to be parallel to the machine table and mill the 0.500" wide by 0.110" deep slot at the bottom rear of the breech block. Keep the edges of this slot exactly on the edges of the 0.500" wide oval slot previously milled.

Keeping the same setup, now mill the 0.375" diameter by 0.100" wide slot in the front of the oval-shaped opening in the bottom of the breech block. Hold the 0.040" dimension as shown, and you are nearly home free. Do not drill and tap for the 5-40 UNF thread at this time. Do ream all four 0.180" diameter holes previously drilled to 0.188" diameter.

Now is a good time to start thinking about machining the 0.625-28 NS threads in the rear of the striker sleeve bore. If you have a boring head, the job is easily done in the mill. Lacking the boring head, it's a lathe job. I prefer doing it in the mill because the setup is faster. In the lathe the setup resembles that used to machine the threads for the barrel in the receiver. In the mill, the setup uses the mill vise. I'll describe that.

Procure a (nominal) 0.500" diameter pin that will fit the 0.500" diameter striker sleeve bore. Install a 1/2" diameter collet in the mill spindle, chuck the pin, and then slide the breech block over the pin. Manipulate the machine table so the vise is positioned under the breech block. Lower the spindle and breech block until the vise can accept the workpiece. Maneuver the table so the vise can lightly grab the part without putting any side thrust on the spindle. Loosen the collet and let go of the pin; then raise the spindle and install an edge finder. Center the pin under the spindle axis and remove the edge finder. Lower the spindle and regrip the pin. Withdraw the pin and then cautiously attempt to reinsert the pin in the bore. If there is any noticeable binding, jockey the table position slightly to ease the pressure. If binding continues, loosen the vise and let the pin readjust the position of the bore axis. Then reclamp the vise and feel for any binding again.

Since exact concentricity of the threads to the bore is not required, this method of positioning is acceptable. Now install a short, stiff boring bar in the collet. The bore diameter for the threads calculates out to 0.579". Bore the hole to that diameter, holding the 0.175" bore depth. Since an intermittent cut is experienced for the first part of the boring cut, feed the tool cautiously.

To cut the thread, install a 60° pointed, 1/2" diameter pin in the collet in the spindle. Then, support the outboard end of the tap with the pin and turn the tap in, using an adjustable jaw wrench. I have both plug and bottoming style taps in this thread size, so I start with the plug tap and finish with the bottoming tool. If you have only the bottoming tap, it's a little harder to start the thread, but with a little care and concentration it can be done.

With this chore successfully done, you can go to the next operation, which is the milling of the 0.625 × 0.250" slot in the right rear wall of the breech block. This is located 0.675" (plus 0.003") from the bottom of the block. The 0.625" dimension is machined so the rear of the slot just kisses the rear edge of the 0.500" wide relief slot milled in the bottom of the breech block at the 0.300" dimension. Blue the area and lay out the outline of the slot parallel to the bottom of the block. Center drill in the center of the slot outline and drill through with a 5/32" diameter drill. Use a 5/32" diameter end mill to mill the opening, holding the 0.250" dimension centered about the 0.678" height dimension. Make sure the 0.625" dimension touches the rearmost edge of the 0.500" wide relief slot.

Now, set the breech block, trigger side up, in the mill vise with the rear face parallel to the spindle travel. Using the shaper tool (sort of), machine the 0.250" radius at the right rear corner of the cavity into a square corner. This is needed clearance for the safety slide rod movement. Now lay the breech block aside temporarily. You are about to tackle another job.

As you are well aware, you have not been asked to form the top contour of either the breech block or the receiver. That is what you should consider at this point. If you are willing to accept my recipe for the receiver shape, well and good. But, if you want to change the receiver shape to something that pleases you more, know what you are getting into. The detail machining on the rear of the receiver block is best left as it is. That means the 72° angle can be machined, holding the 5.05" length dimension. The rest of the back end detail can be machined also.

It should be noted here that the 7/16-20 UNF threaded hole goes in perpendicular to the angled rear face of the receiver block, while hole "B" goes into the receiver block parallel to the bottom face of the block. Note also that hole "B" breaks into the 7/16-20 UNF threaded hole. This means a 3/16" diameter end mill is used to plunge mill, parallel to the bottom face, into the block until solid metal is reached near the bottom of the tap drill for

the 7/16-20 thread. This cleaned-up surface is then center drilled and hole "B" is drilled through on the 0.678" and 0.483" location. The rest of the back end detail machining is straightforward and should be no problem.

The problem remains about the top contour of the receiver and breech block. I have found the best way to shape them is to shape them together. I insert the breech block into the receiver slot and put a small parallel clamp on the receiver in the area of the receiver side walls. The side walls spring enough that the breech block is solidly held in place in its slot. I then blue the receiver and lay out the top contour. It takes a while to do, but the best way to rough the top shape is to band saw it. On my first receiver I didn't have a band saw, so I spent most of one day grinding the thing to its rough shape. Whatever you do, remember my warning about keeping solid receiver metal behind the striker sleeve bore.

I produce the rounded transverse shape of the receiver top by rough grinding. When I'm close enough to start filing, I use a double-cut bastard file (rough cut) to work the block into its nearly final shape. Then it becomes a draw filing project to arrive at the finished but unpolished shape. What I would like to impart to you is that if your receiver shape gets very exotic, it gets quite difficult to do the rough and finish filing – and draw filing may be impossible, at least on some areas of your receiver. What I am trying to say is that you would be wise to balance your choice of shape with the amount of work you are thereby imposing on yourself.

Finish-shaping the receiver is a big job. The good news is that, when you're done, you have two parts that are neatly contoured. When you are done and have slipped the breech block out of the receiver, you will find you have produced some razor sharp edges around the periphery of the breech block slot in the receiver. There's nothing to be done but to take some Swiss pattern jeweler's files and produce a nicely rounded (about a 1/64" radius) edge around the entire top outline of the breech block slot. I feel I should ask, also, if you remembered to machine the stress relief radii in all the sharp corners of the breech block slot and the extractor guide opening.

The next thing to do is to cut the clearance groove in the receiver rear wall that runs between the center line of hole "B" and the right-hand edge of the 0.250 × 0.500" oval slot machined in the bottom rear of the receiver block. That's the 0.090" wide × 0.080" deep slot that shows in the rear area of the bottom view of the detail drawing. It has to be put in with the shaper tool (sort of) and it's too wide to form with one pass of the tool. I'd much recommend that a narrower faced shaper tool be ground and the slot be cut in two adjoining passes, using no more than 0.002" depth of cut per stroke.

Next comes the job of cutting the 0.275 × 0.375" slot in the bottom rear face of the receiver, holding the 3.900" dimension. Lay out this location from the center line of the 0.250" diameter cross pin hole and center drill and clearance drill a 0.250" diameter hole through to the oval slot. Using a 0.250" diameter end mill, open up the 0.250" drilled hole to the 0.275 × 375" dimensions. Then, using a small pillar (safe edge) file, square out the corners of the milled slot.

Now, comes the job of laying out and milling the opening in the bottom front of the part of the receiver block. Drill a 3/16" diameter clearance hole anywhere within the layout perimeter, install a 3/16" diameter end mill in the spindle and mill the profile shown, holding the called-for dimensions.

Last, make up an extension holder for a 3/8" shank diameter end mill from a 5.0" long piece of 3/4" diameter cold rolled steel. Cross drill and tap for a 10-32 NC setscrew. Install a 5/16" diameter end mill in this holder and set it into the spindle of your mill. Using an edge finder, pick up the center line of the receiver block, set at the proper 30° angular tilt and clamped in the vise. With this tool, it is just possible to reach the area to be machined for the extractor clearance slot.

Hold the 0.325" width of the slot, keeping the slot centered about the receiver center line. Then, mill the 0.12" corner radii on both bottom sides of the block, skipping the cross pin hole area. Finally, with the receiver upright in the mill vise, use an edge finder to locate the position of the two 8-36 holes in the front face of the receiver. Center drill, and drill No. 29 (0.136" diameter) ×0.63" deep. Tap 8-36 NF × 1/2" deep.

At this point, more work is to be done on the breech block. One surface on the breech block has been left unmachined. This is the surface "B" marked on the detail drawing. Blue the top front face of the breech block down to the 0.400" wide oval slot. Then assemble the breech block into the receiver slot with the bottom of the breech block and receiver flush. Clamp the

receiver side walls to hold the breech block immobile in the receiver. Get your scriber and, looking down the threaded barrel bore, scribe an arc at the bottom of the 1.009" through-bore diameter. This will break into the 0.400" wide oval slot in the front face of the breech block by about 0.12", but that is okay.

Disassemble the breech block from the receiver and make a milling machine setup, setting the rear face of the breech block on the 7.333° angle block with the tilt angle in the proper orientation. Clamp the vise tight and take light machining cuts until surface "B" approaches its proper level, remembering that this surface will encroach on the end of the 0.400" wide slot by about 0.12". Remove the part from the vise and lightly file break all the sharp edges. Then lay the part aside. You will mill the "loading groove" in the top of the block, drill and tap the 5-40 NF threaded hole, and drill and form the firing pin hole geometry at a later time.

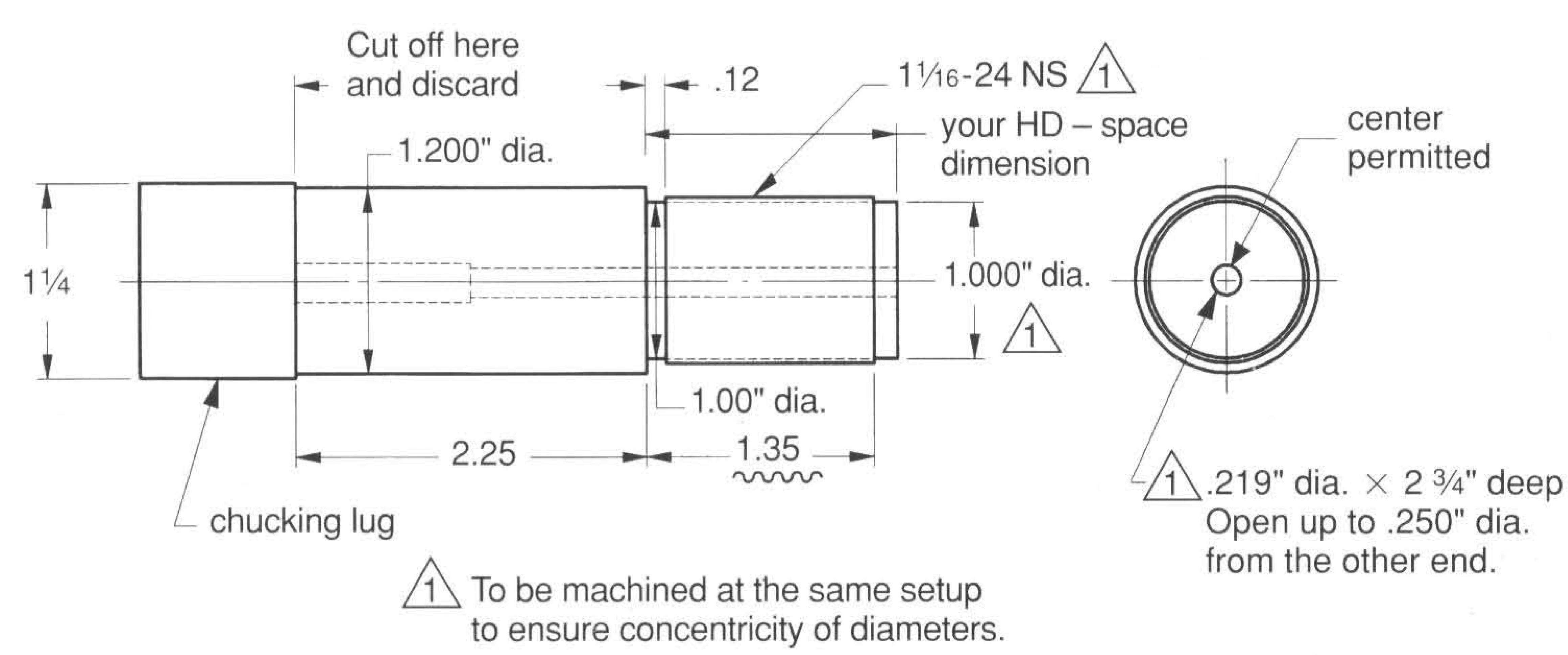
This is the time to make another tool. It's really the stub barrel, but it functions as a tool and an educational and practice project, all in one. Get a piece of free-machining cold rolled steel about 5.0" long and 1.250" in diameter. As you can see from the drawing of Tool 4, all the real machining takes place on the chamber mouth end of the stub barrel. But first, chuck the 1.250" diameter hunk of cold rolled steel in your three-jaw chuck, and take a cleanup cut on the OD for a length of 3.5".

Face the end, of course, and make sure you have a good surface finish on all machined areas of the part. Reverse the part in the chuck, and make ready to machine the chamber end of the barrel, realizing that in the process you are going to learn how to establish the "head space" of the action, machine the "real" barrel shank details, and cut the extractor slot.

You'll learn how to chamber your real barrel and how to fit the barrel and extractor to the action. I'm assuming you have decided what your barrel caliber will be and what specific cartridge you will be chambering for. You'll have to know that before you can order your chambering reamer and your barrel blank.

Slip the breech block back into the receiver slot and clamp it as before. Now get out your depth micrometer, and very carefully measure the distance from the barrel-stopping face to the face of the breech block. Measure it several times, recording your readings, and then get a brass rod and lightly tap the face of the breech block a few times. Measure again several times to make sure of your dimension, and then compare these readings with your first set.
If you are sure you have reliable, repeatable readings, you are ready to begin. For illustration purposes, assume your micrometer reading is 1.7056". Face the end of your workpiece, and know you are now going to produce the major diameter of the 1.062-24 UNEF thread and a barrel-stopping shoulder surface that is exactly 1.7056", from the surface you just faced. This will require the help of an indicator, to be installed presently on the lathe.

For now, start the proceedings by taking a cleanup cut on the rough diameter, to just under the chucking diameter. Turn this diameter to a length of 3.6". Now turn a 1.062" diameter to a length of 1.65". Exchange your turning tool for a parting-off tool. Set a dial indicator in place on the lathe with the parting tool positioned at the 1.65" shoulder position, so you can measure further small advances of the lathe carriage. Now measure carefully what your 1.65" dimension really is and start to sneak up on the required 1.7056" dimension, while also undercutting the 1.060" diameter down to 1.000" diameter × 0.10"




Tool 4
STUB BARREL
CRS

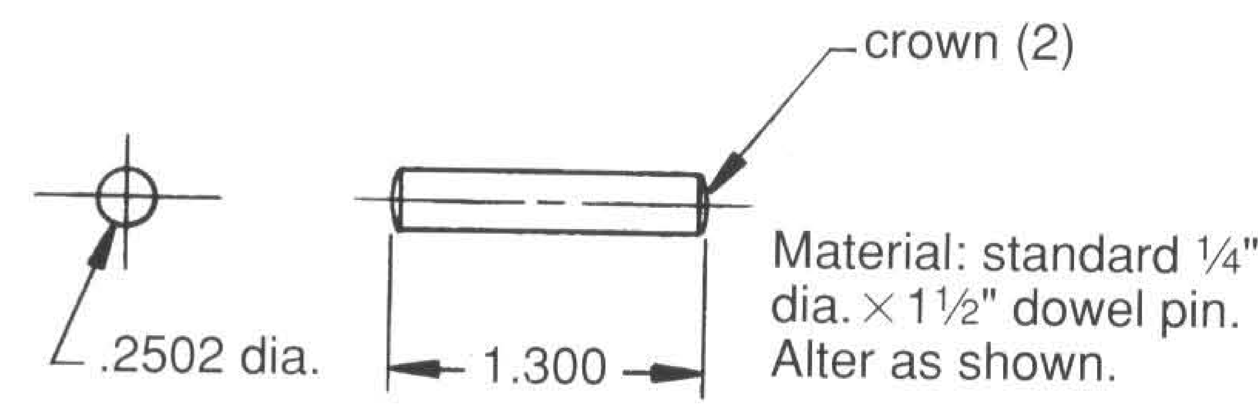
wide, to provide a relief groove for the threading tool. Use your depth mike as carefully as you can in getting to the 1.7056" length. Don't settle for 1.7044" or 1.707".

Now, set up the lathe to cut the 24 tpi thread. When you have the lathe all set, start cutting the threads. These threads will be completely finished in the lathe, using the receiver threads as a gage for proper fit. What is needed here is a snug, straight, shake-free fit to the receiver. Do it well, imagining that is your real barrel, because soon that's what you will be working on. At this point, center drill the chamber end of the stub barrel and drill a 7/32" (.219" diameter) hole down the bore axis as far as you can reach. If you can't get all the way through, reverse the barrel in the chuck and drill from the front with a 0.250" diameter drill.

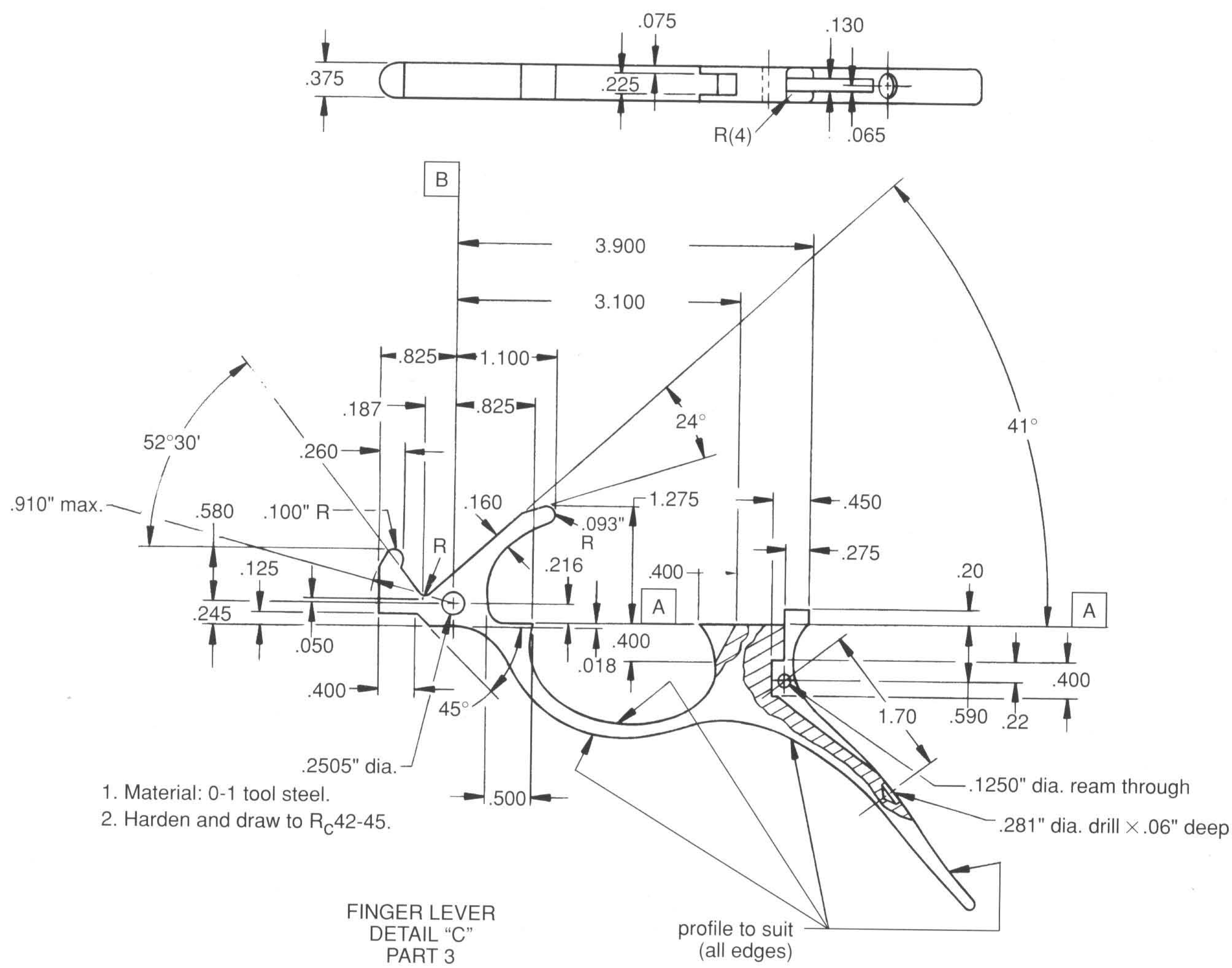
For now, this finishes the work on the stub barrel, unless you want to cut some wrench flats on the front end of the barrel. I usually do as it helps to screw the barrel in good and tight. That's not what you'll do with the real barrel, but it's good enough for now.

Make up a temporary cross pin (Part 5). Make it out of aluminum or brass and make it about a half-thousandth smaller in diameter than the detail drawing calls for. Set this part carefully aside, because you'll need it soon, when you have completed the finger lever.

Now, screw the stub barrel into the receiver and slide the breech block into place. You can feel the breech block lock into place with a slight interference fit, if you lightly tap the breech block with a brass rod. That's the kind of fit you want the finger lever to provide, when it shoves the breech block up into place. I propose you make the finger lever (Part 3) next. You can let your artistic urges out of the closet, here, if you wish. The finger




CROSS PIN
PART 5

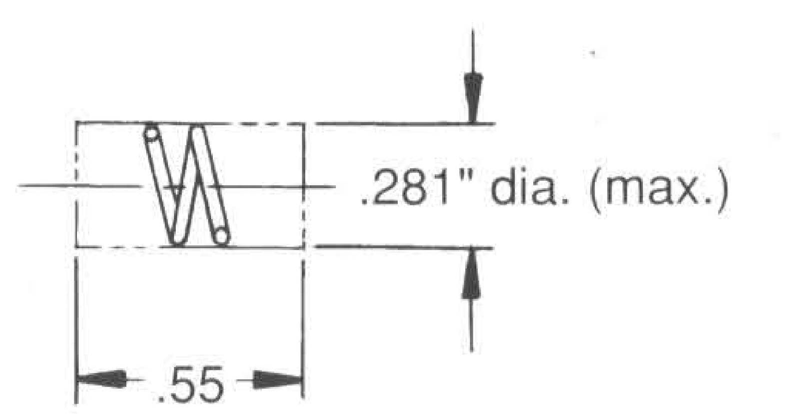



FINGER LEVER
DETAIL "C"
PART 3

lever design I show is merely one man's idea of what the thing should look like.

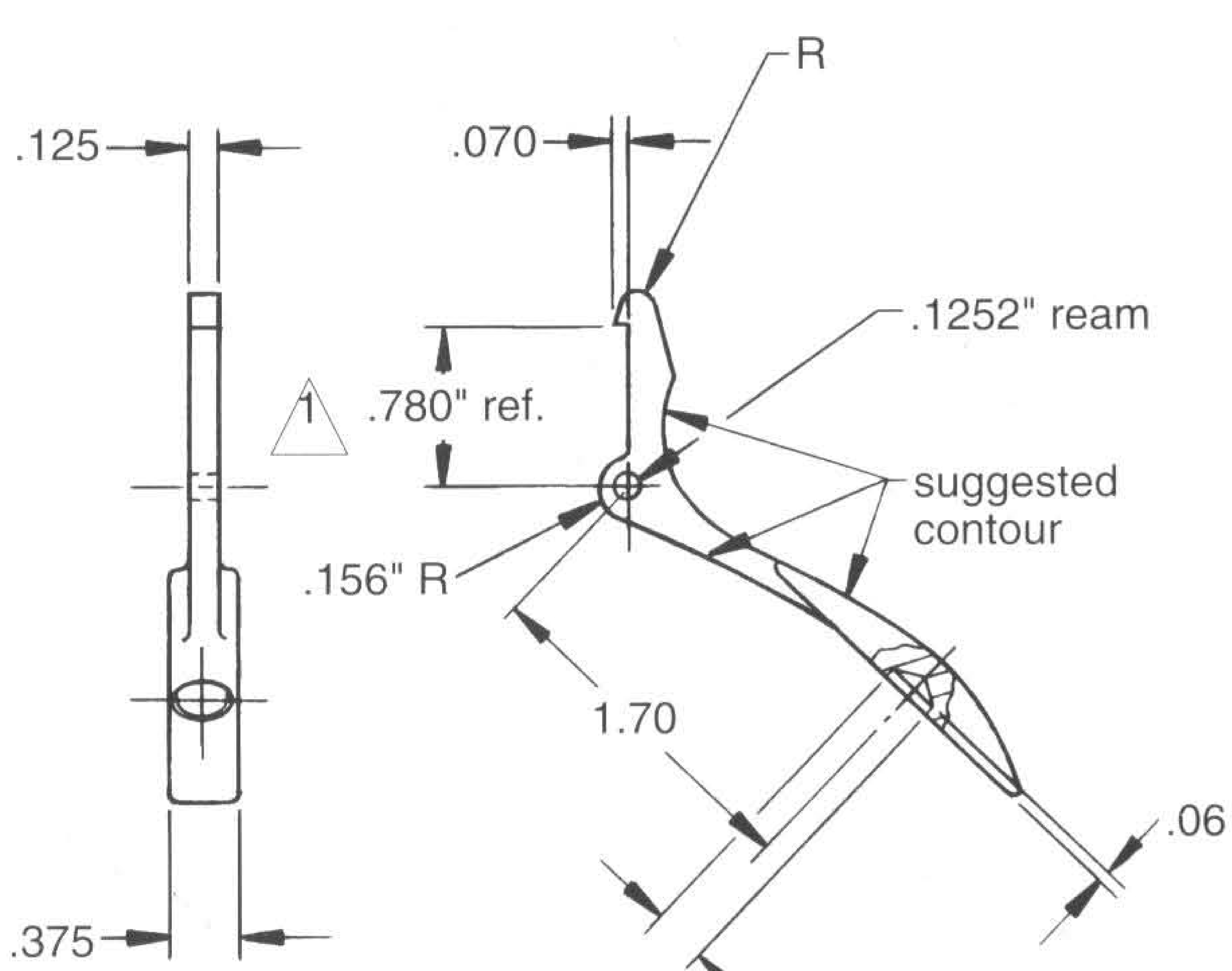
I start out by making a paper tracing of the outline, right off the drawing. Then, I take a sharp prick punch and lightly punch through the paper into the 3/8" thick × 2-1/2" wide piece of steel I'm going to take it out of. Then I get rid of the paper template, blue the punch-marked side of the steel and use a draftsman's curve to connect the punch marks. Now, I center punch the location for the 0.2505" diameter hole and drill a letter C (0.242" diameter) hole through. Next, I set the blued blank up on my surface plate and pick up the center line of the 0.242" diameter drilled hole. Then I come down 0.216" and scribe the real location of the reference surface marked as "A" on the drawing. Then I ream the .2505" diameter hole.

Now, you can consider the band sawing of whatever finger lever shape you have selected. The band sawing being done, it's time to do a bunch of filing. A number of years ago, having decided I no longer had a love affair going with a file, I located and bought a used Keller die filing machine. What a wonderful addition to my shop that was. Now, it's a pleasure to kick out shapes like the finger lever. It's not impossible by hand, but it's much faster by machine.




1. Material: .035" steel spring wire.
2. Spring helix: 11 turns/inch

FINGER LEVER
LATCH SPRING
PART 17



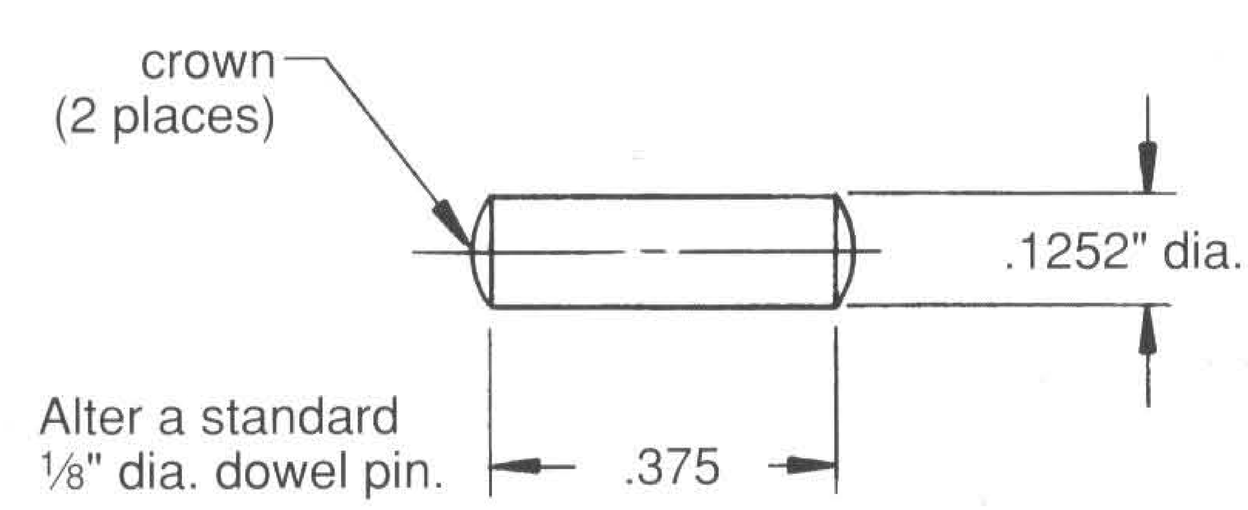

1. Material: Type 0-1 tool steel.
2. Harden and draw to 50-53$R_C$.
1 Carefully hand-file this dimension for proper fit at assembly, before heat-treat.

FINGER LEVER LATCH
PART 18

While you are filing, you must establish the 3.900" dimension carefully. Watch this length and the mating 0.275" dimension to establish a good fit to the receiver, often measuring the progress of the work. When you finish filing to the shape you want, mill the two slots shown on the detail print. They are not hard to do except for the deep part of the finger lever latch clearance slot.

Needed here is the longest flute, 1/8" diameter end mill you can find, with a little hand grinding on the shank to help lengthen its reach. But work carefully, and you'll find it's all possible to do. With the slots milled into position, you can establish the location for the 0.1250" diameter reamed hole. Center drill, drill and ream this hole, and then lay out the position for the spring anchor hole. Center punch this location deeply so the drill won't wander and then drill the 0.281" diameter × 0.06" deep hole. Now, with maybe a little more cosmetic filing, the finger lever is completed. If you quickly make some small parts, you'll be able to see how the finger lever will work with the breech block.

The two pins (Parts 12 and 13) are next. They won't take much time. It doesn't say it on the drawing, published in the July/August 1994 issue, but a small center is permissible on the outboard end of each pin for support. When Part 13 is done, install it into the breech block and go on to Part 12. The middle diameter of this pin is adjusted in size until the camming surface on the finger lever shoves the breech block up into its interference fit position in the receiver. I'd suggest you start with a diameter of about 0.140". If the finger lever won't close with that diameter in the upper hole in the breech block, reduce the diameter a few thousandths and see what effect that has on the closing of the finger lever. Eventually,




FINGER LEVER
LATCH PIN
PART 25

you'll get close to having the finger lever end up in the proper position, but it doesn't hurt a bit to spring the finger lever up that last 0.02" or 0.03".

By now, you'll have learned the inevitable. There's plenty of hand filing to do on this project. If you can stand to do a little more, the next part to make is the finger lever latch.

Before the finger lever latch (Part 18) is started, an important dimension must be established. With the breech block assembly and the finger lever installed in the receiver (and with the finger lever snugged up into its uppermost position), make a surface plate setup that allows you to measure the distance from the center line of the 0.1250" diameter reamed hole in the finger lever to the bottom surface of the oval-shaped hole in the rear of the receiver. This distance corresponds to the 0.780" dimension (REF) shown on the detail drawing of Part 18. Your dimension may not be 0.780", so it's important to find out what it really is. Like the boys in the shop used to say, "It's easy to make a tool for taking off metal but it's hard to make one for putting it on," so knowing this dimension may save you from making the finger lever latch over several times.

The finger lever latch is also a part gunmakers lament as being of a shape so hard to clamp that it can't be made. That judgment is really not warranted in this case, but you may have some fun before you carve one out you like. Other than the setup problems you may encounter and the attention you must pay to achieving the 0.780" (REF) – or whatever you measure – dimension, there's not much involved in making this part other than a lot more filing. Establish the outside perimeter shape via the paper template approach and have at it. When it's done, take your caliper and visit your local hardware store. Poke through their stock of standard compression springs until you find one of the correct diameter and wire size. Bring it home, modify it for proper length and end configuration and you have Part 17 (finger lever latch spring) in hand.

Then modify a 0.1250" diameter dowel for length, and you have Part 25 (finger lever latch pin). Put all of the above together and in their proper respective places and you'll be able to get some notion of what your action will eventually look like. When I reach this stage of completion with an action, I always feel as if I have reached a minor milestone. It's permissible for you to feel a little proud, also.

It's time now to start considering the action parts that will fit inside the breech block. The one that may cause the biggest problem is the striker spring (Part 22). If you are a purist in your manufacturing approach, you may wish to wind this spring. It would be presumptuous of me to try to tell you all about spring winding on one page. you can acquire a fine education in this art, however, by studying the May/June and July/August 1987 issues of *The Home Shop Machinist*. Two articles are contained therein, by Kozo Hiraoka, containing all the information you need to know about winding technique and simple winding tools that work. With this knowledge in hand, all you need is a roll of 0.060" diameter spring wire and some practice. But, there is another way. Enco Manufacturing Company, 5000 West Bloomingdale, Chicago, IL 60639, carries a line of "die springs" in its inventory that are useful. These are stripper bolt springs that are used in conjunction with the stripper plate assembly on blank-and-pierce dies. The particular spring of value is the series No. 400-5105. It is 3/8" diameter and 2-1/2" long, painted green for identification, and is priced at $1.30 a copy. Buy a spring of this variety, modify it for length and soak it in paint stripper to get rid of the green paint and you have a striker spring.

The striker sleeve (Part 21) is a simple drilling, facing and milling job. The striker sleeve locknut (Part 23) is another lathe job, complicated slightly by the hex wrench hole to be filed in it. The striker (Part 19) starts out as a lathe job for the 0.440" OD and the 0.375" ID. Mill the front shape of the striker and use the shaper tool to form the unturned 0.440" diameter. Don't put the 1/4-28 NF thread in yet. That comes later. Now file the front radius, detailed in View A-A, and drill the lightening holes as shown. Finally, lay out the 0.340" and 0.875" dimensions of the striker sear, and mill or file to the layout line, keeping the caveat of note No. 4 in mind.

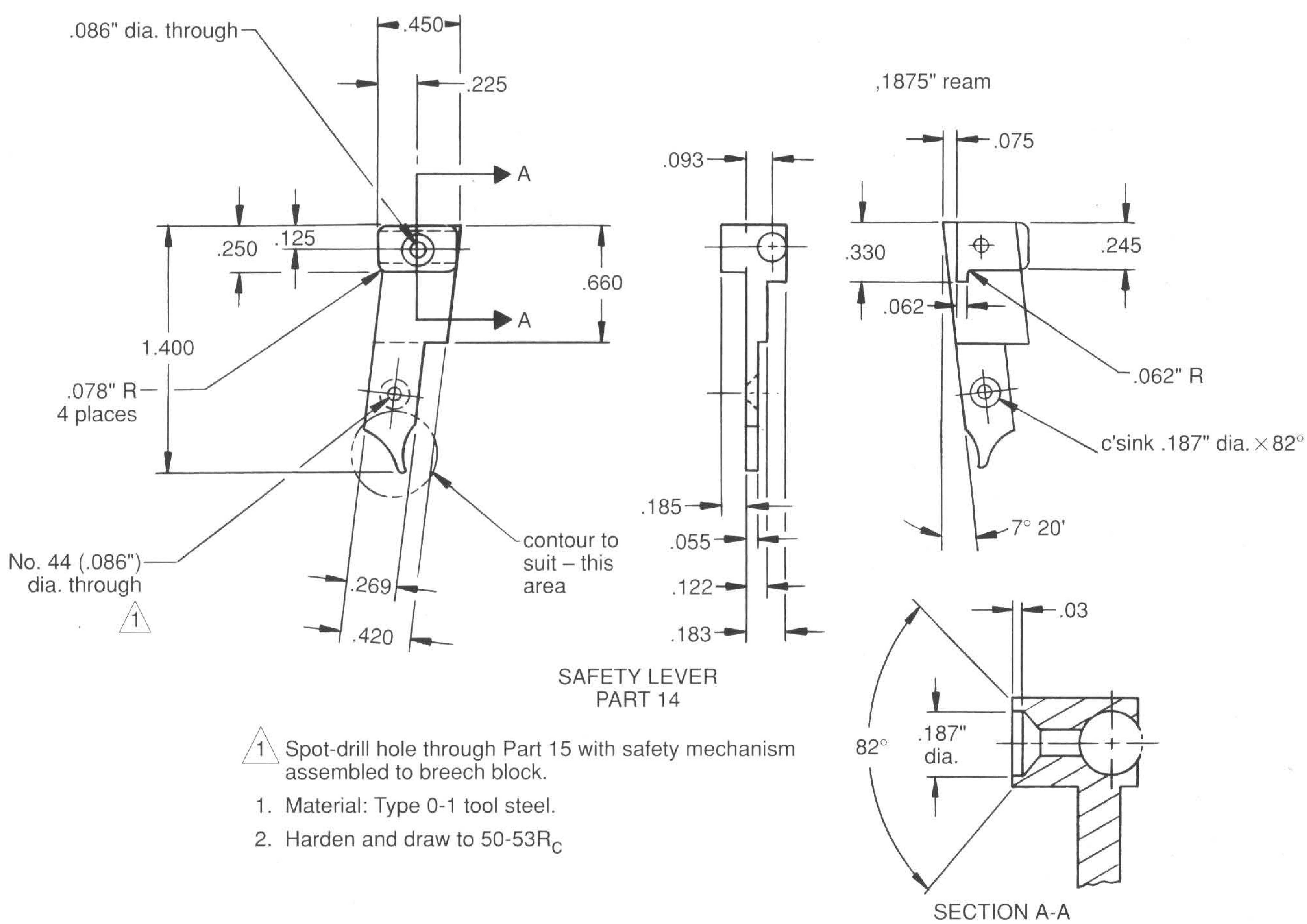
What's left after this is only the firing pin (Part 20), another simple lathe job, with just a screwdriver slot to be cut in the back end. Assemble the parts you have just made into the striker sleeve bore. Remember when you made the stub barrel for the action, you drilled that 0.219" diameter hole axially down the barrel? Make a 0.219" diameter transfer punch from a length of 0.250" diameter drill rod, and harden the tip of the punch. Now, with the

breech block assembly and the finger lever assembly in place in the receiver and with the breech block solidly in its uppermost position, transfer punch the firing pin hole location into the front face of the breech block.

Disassemble the breech block assembly and finger lever assembly from the receiver. Set the breech block in a milling or drill press vise with the 7.333° angle block tilting the breech block at the proper orientation to make the striker sleeve bore parallel with the spindle axis. Center drill at the transfer punch marked location and then drill a 0.070" diameter hole through the face of the breech block, into the striker sleeve bore.

Since the striker is in place and is being held in its forward position by the striker spring, the 0.070" diameter drill point will mark the face of the striker for the proper location of the 1/4-28 NF threaded hole you were asked to leave out when you did the original machining. Now, you can disassemble the breech block assembly itself, and drill and tap 1/4-28 NF hole in the striker and be reasonably sure everything will line up the way it should.

Next on the manufacturing agenda are the items that make up the automatic safety assembly. The first of these is the safety slide rod (Part 26). It is made of 3/16" diameter, type 0-1 drill rod. The detail drawing calls out an OD of 0.186". This is because of possible misalignment of the 0.188" diameter holes in the breech block. The first thing to do, therefore, is to check the fit of the rod in the holes. Any hard binding of the rod in the hole




SAFETY LEVER
PART 14

1\. Spot-drill hole through Part 15 with safety mechanism assembled to breech block.

1. Material: Type 0-1 tool steel.
2. Harden and draw to 50-53$R_C$

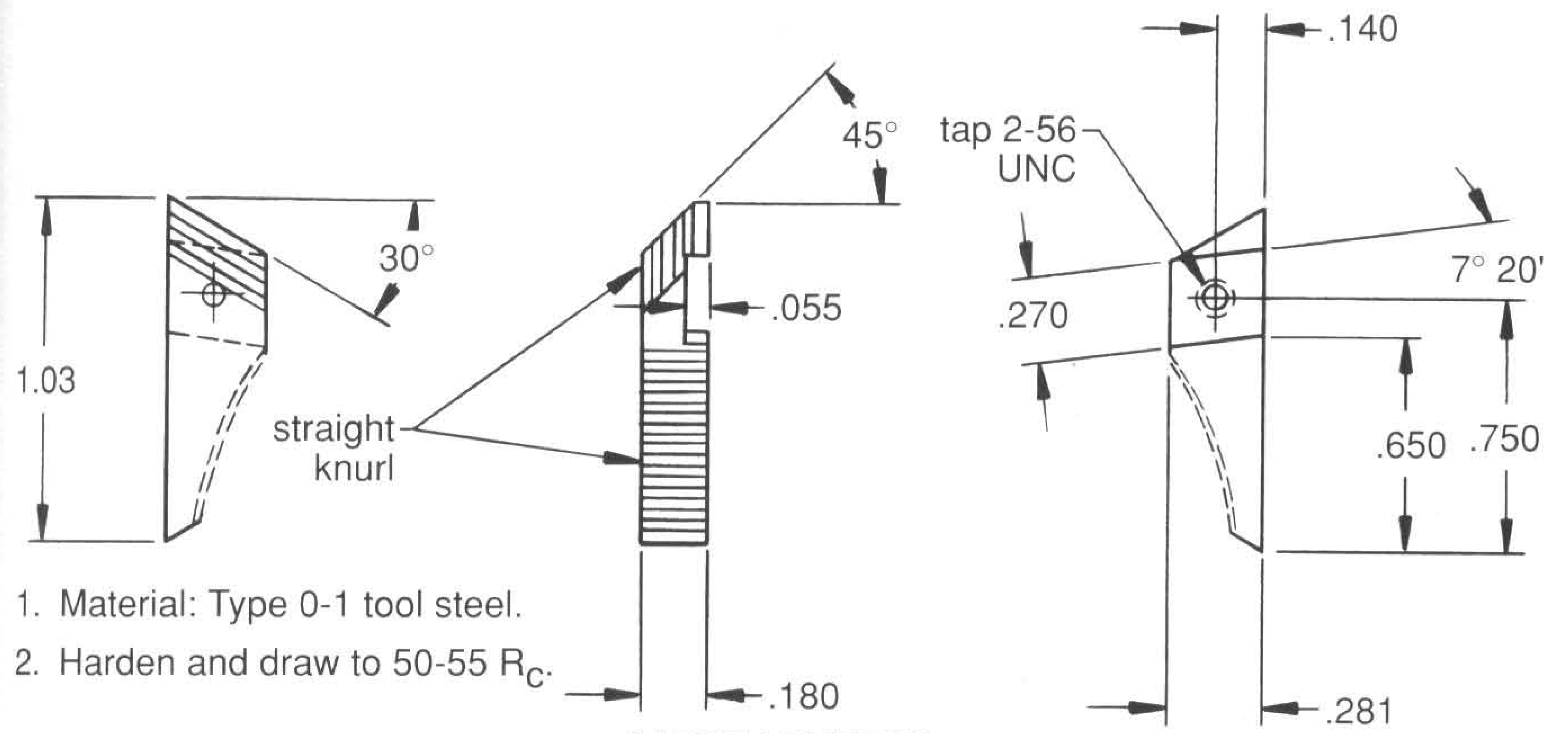
is not allowed. What is desired is a light push fit of the rod in the holes.

The rod is not fitted with a spring detent catch, for the sake of simplicity, so it needs the light friction fit of the rod to the holes to make it stay in its selected position. Therefore, file to reduce the OD of the rod to make it fit the way it should. An examination of the detail drawing shows three flats milled on the part. These are easily machined if the rod is clamped horizontally on the vertical surface of an angle plate and rotated 90° for each cut.

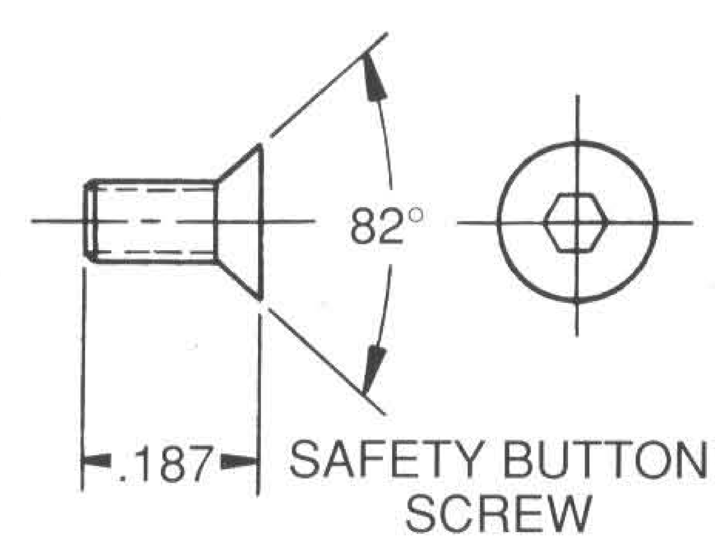
After the slide rod is trimmed to length, the 2-64 NF threaded hole can be center drilled, drilled and tapped. The end details of the rod are easily file finished, but in a later operation.

The safety lever screw (Part 38) is easily made. The secret here is to chuck a standard 4-40 screw in the lathe, holding on the threads. Turn the head diameter to 0.187" diameter and release the part from the chuck. Then install a drill chuck in the tailstock of the machine, and grip the screw in the chuck, holding again on the threads. Then slide the tailstock up to the chuck and grip the now centered and aligned screw on the small flat area you machined on the head. Now, you can take light cuts, successively, to get the OD down to 0.086" diameter, which is 2-64 size.

All that remains is to put the 2-64 die in a sliding tailstock chuck, and cut the thread. It's a cinch to make specially sized, hex head screws in this manner, since they are tough to buy one at a time. The next part is the safety

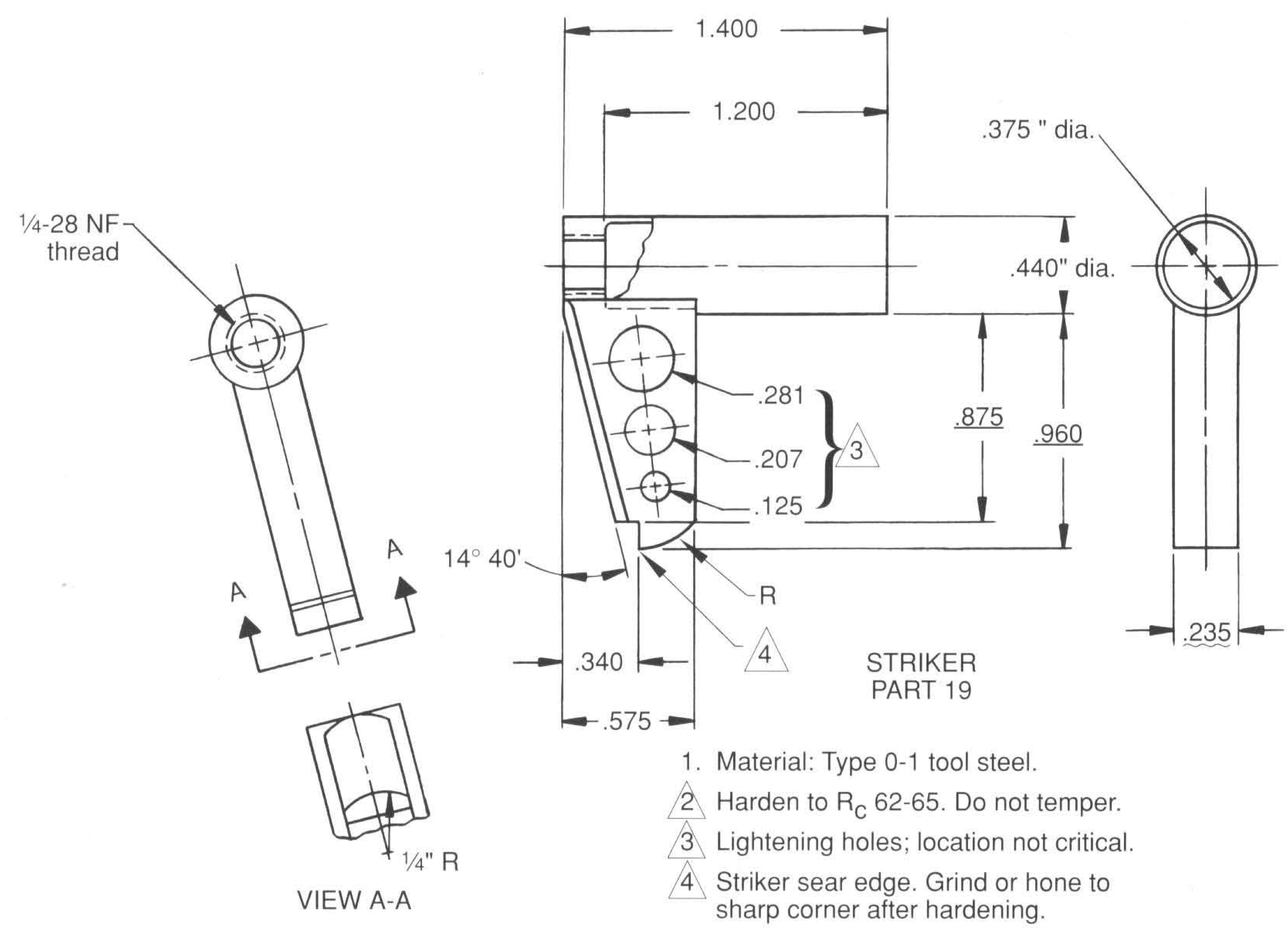



SAFETY BUTTON
PART 15



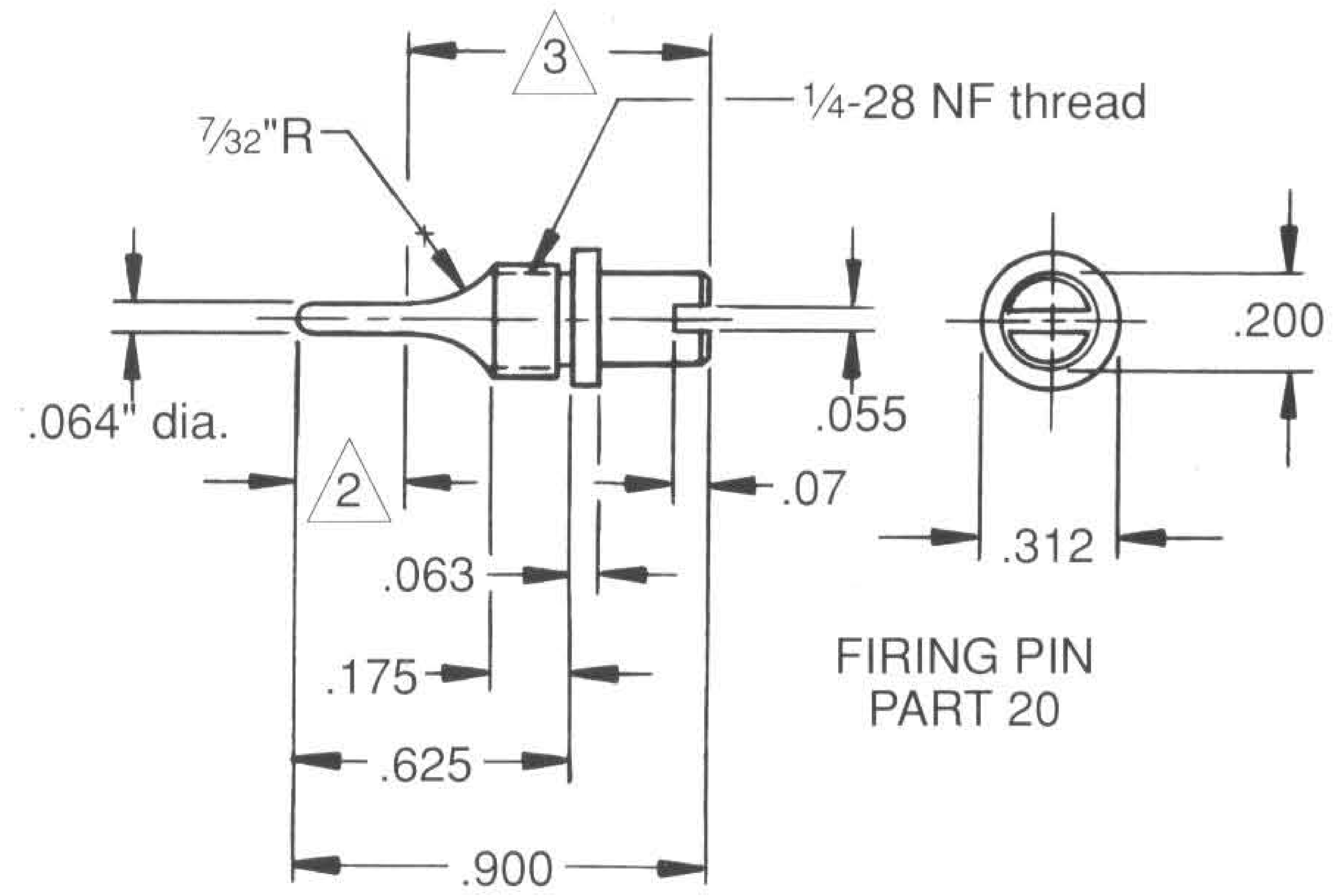

SAFETY BUTTON SCREW
PART 16

Standard steel, 2-56 UNF SHFH screw.




STRIKER
PART 19

1. Material: Type 0-1 tool steel.
2. Harden to $R_C$ 62-65. Do not temper.
3. Lightening holes; location not critical.
4. Striker sear edge. Grind or hone to sharp corner after hardening.

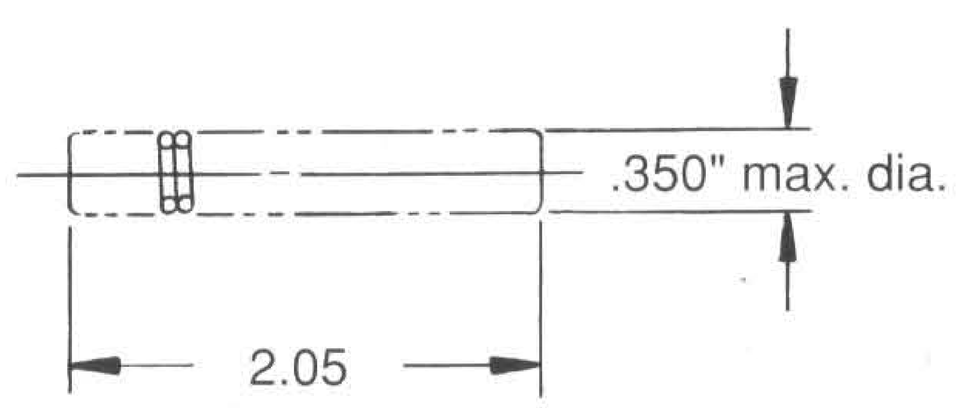



FIRING PIN
PART 20

1. Material: Type 0-1 tool steel.
2. Leave hard this area at $R_C$ 60-65.
3. Draw hardness this area to $R_C$ 40-45.
4. Firing pin length left oversize to allow length adjustment at assembly for proper primer ignition.

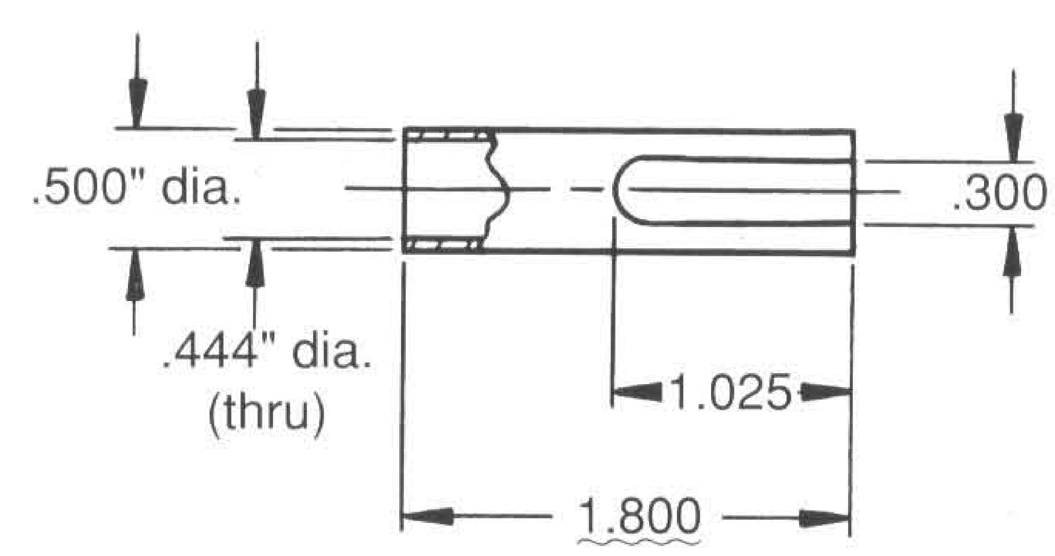
lever (Part 14). I can't use my milling machine vise to make parts like this, because of the generous chamfers on the sides and edges of my vise jaws. Therefore, I use a small drill press vise with sharp-edged jaws to hold the part and clamp the drill vise in the milling machine vise. If you use this technique, you won't have much trouble making the safety lever.

There are two 0.086" diameter holes drilled in the part, and both call for countersinks. Do not countersink the 0.086" diameter hole in the lever part of the safety lever. That is best done in a later operation. The safety button (Part 15) is the last of this group of parts to be made. The two things to concern you on this part are the 7.333" angle slot in the part and the funny profile with the straight knurl. This part is best made clamped in the drill press vise.



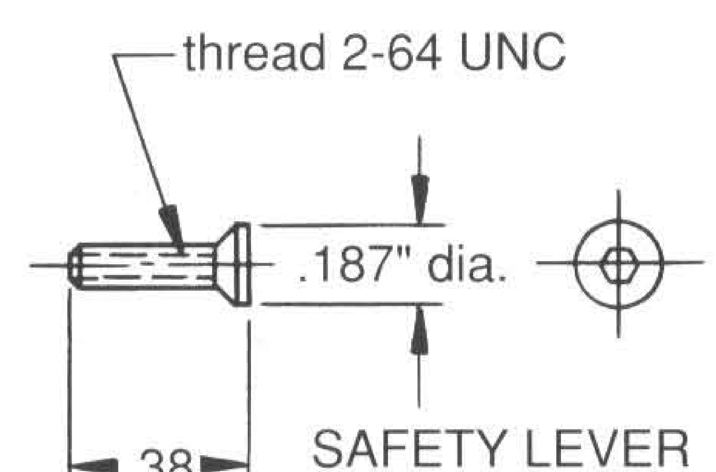

STRIKER SPRING
PART 22

1. Material: 0.060" dia. steel spring wire.
2. Spring helix: 11 turns per inch.
3. No. 400-5105 spring; purchase from Enco Mfg. Co., 5000 West Bloomingdale, Chicago, IL 60639



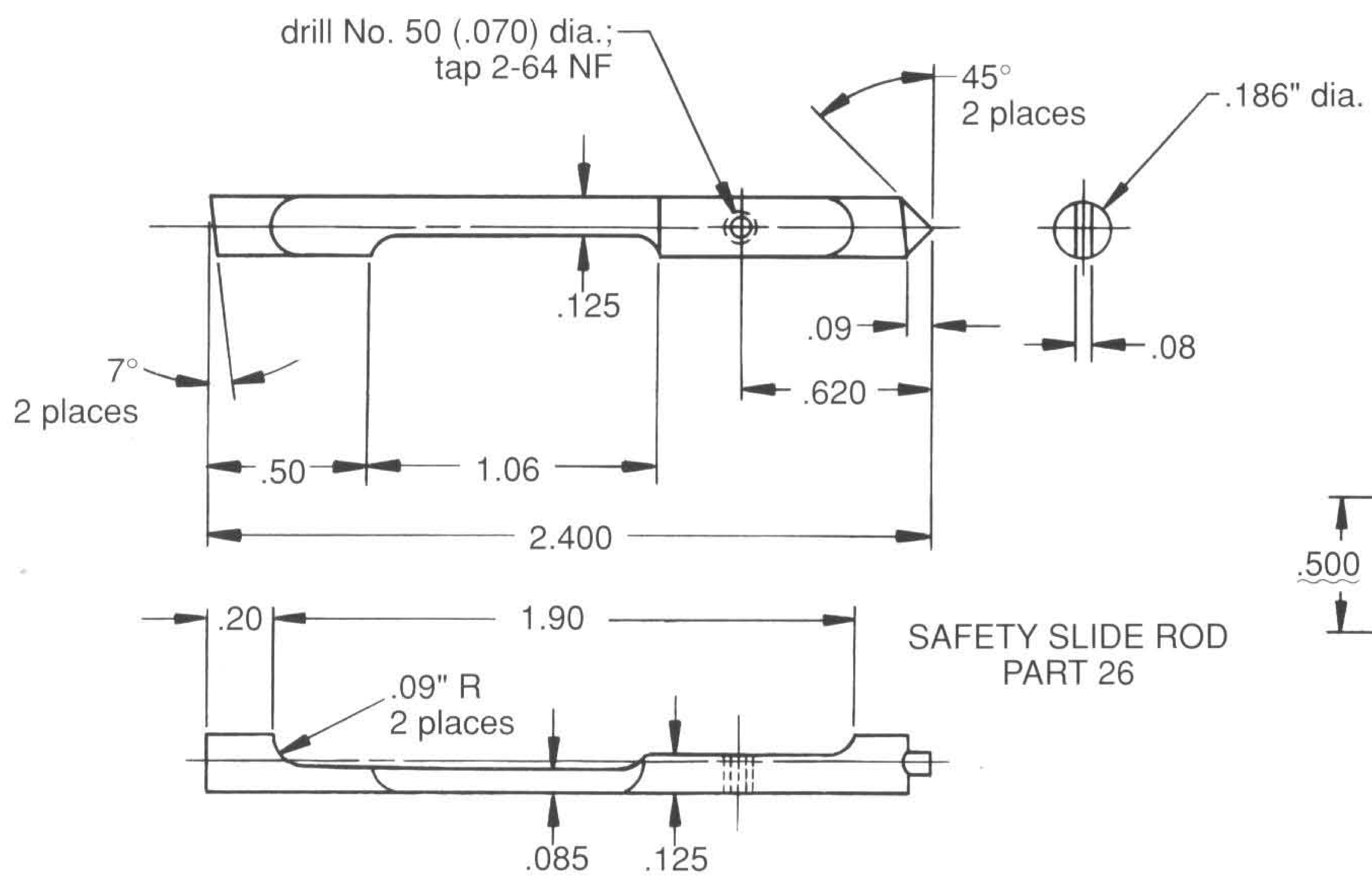

STRIKER SLEEVE
PART 21

1. Material: Type 0-1 tool steel.
2. Harden and draw to $R_C$ 50-52.



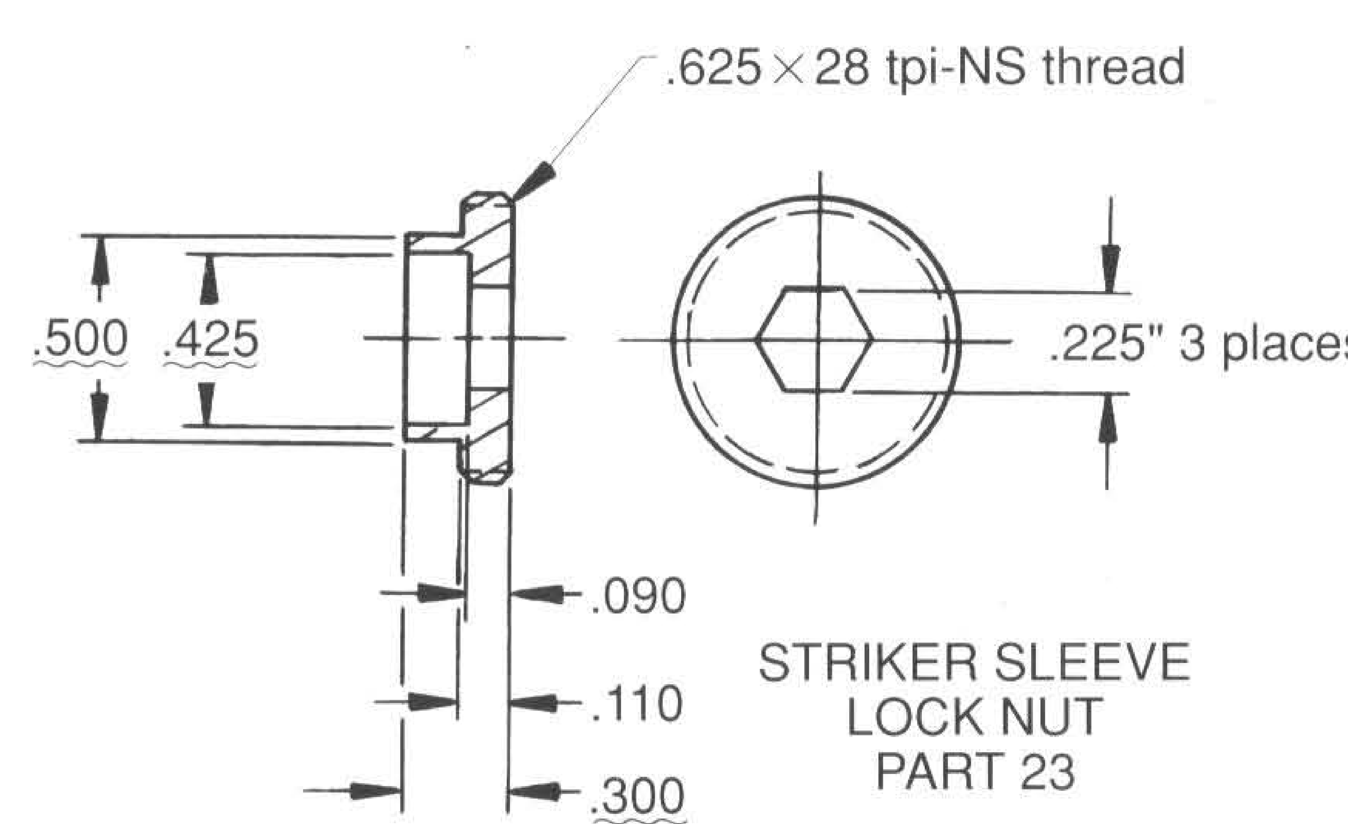

SAFETY LEVER
SCREW
PART 38

Alter standard 4-40 FHSH screw as shown.




SAFETY SLIDE ROD
PART 26

1. Material: Type 0-1 drill rod.
2. Harden and draw to 50-53 $R_C$.




STRIKER SLEEVE
LOCK NUT
PART 23

1. Material: Type 0-1 tool steel.
2. Harden and draw to $R_C$ 52-55.

Start it out as a rectangular block, 1.03×0.281 ×0.180". Then mill the slot, holding the width to a nice tight slip fit to the lever part of the safety lever. Mill the 30° × 45° compound angle using the "drill press vise in mill vise" trick and put in the straight knurl using the drill vise clamped to an angle plate, along with the shaper tool (sort of). Don't drill or tap the 2-56 NC thread yet. It's better done later.

The safety button screw (Part 16) requires no comment other than that you need one.

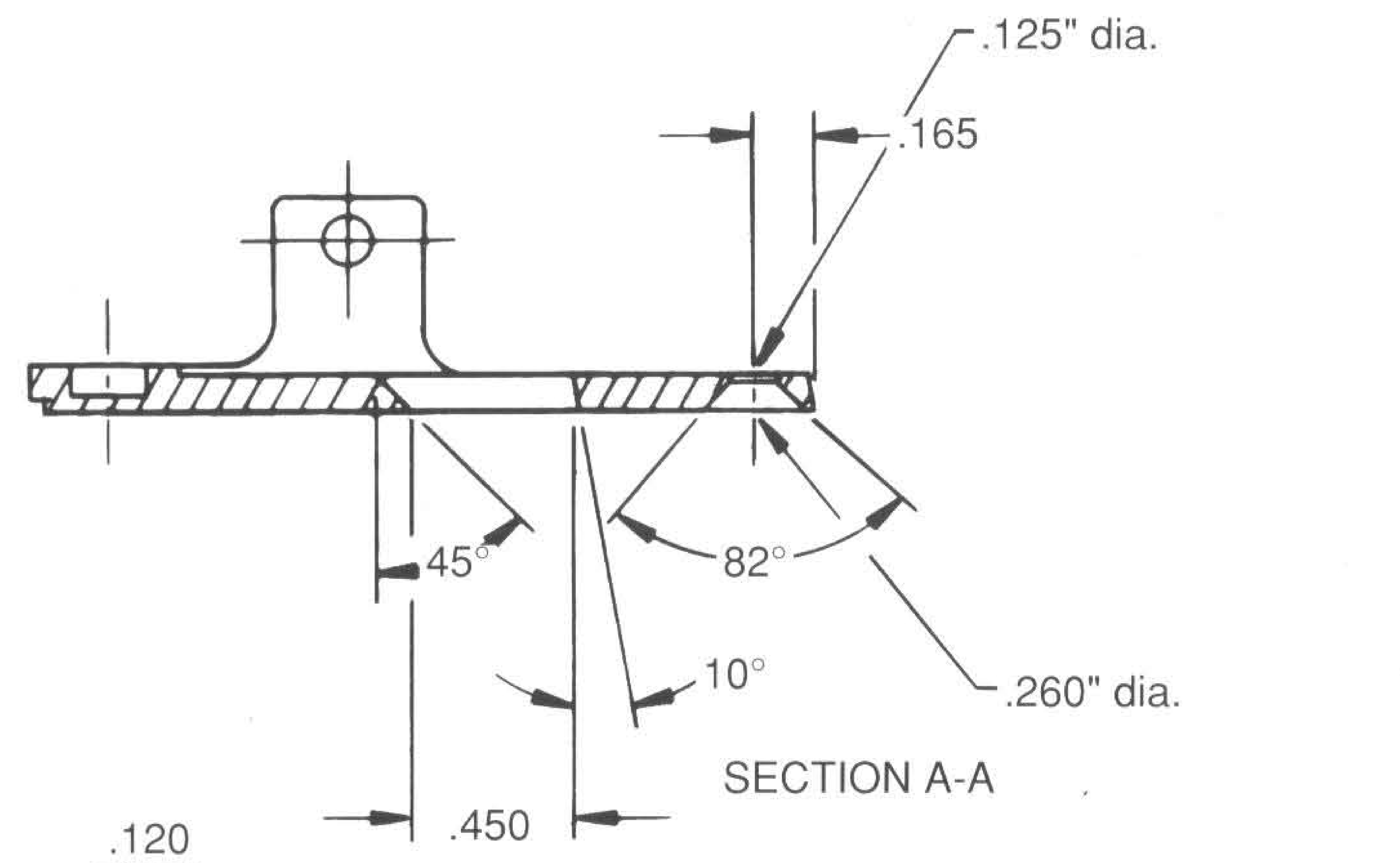
The trigger assembly group is next, and is comprised of the trigger plate, trigger, trigger travel adjust screw, trigger pin, trigger spring, and trigger plate screw. The parts of most consequence to acquire are the trigger plate (Part 6) and the trigger (Part 7).

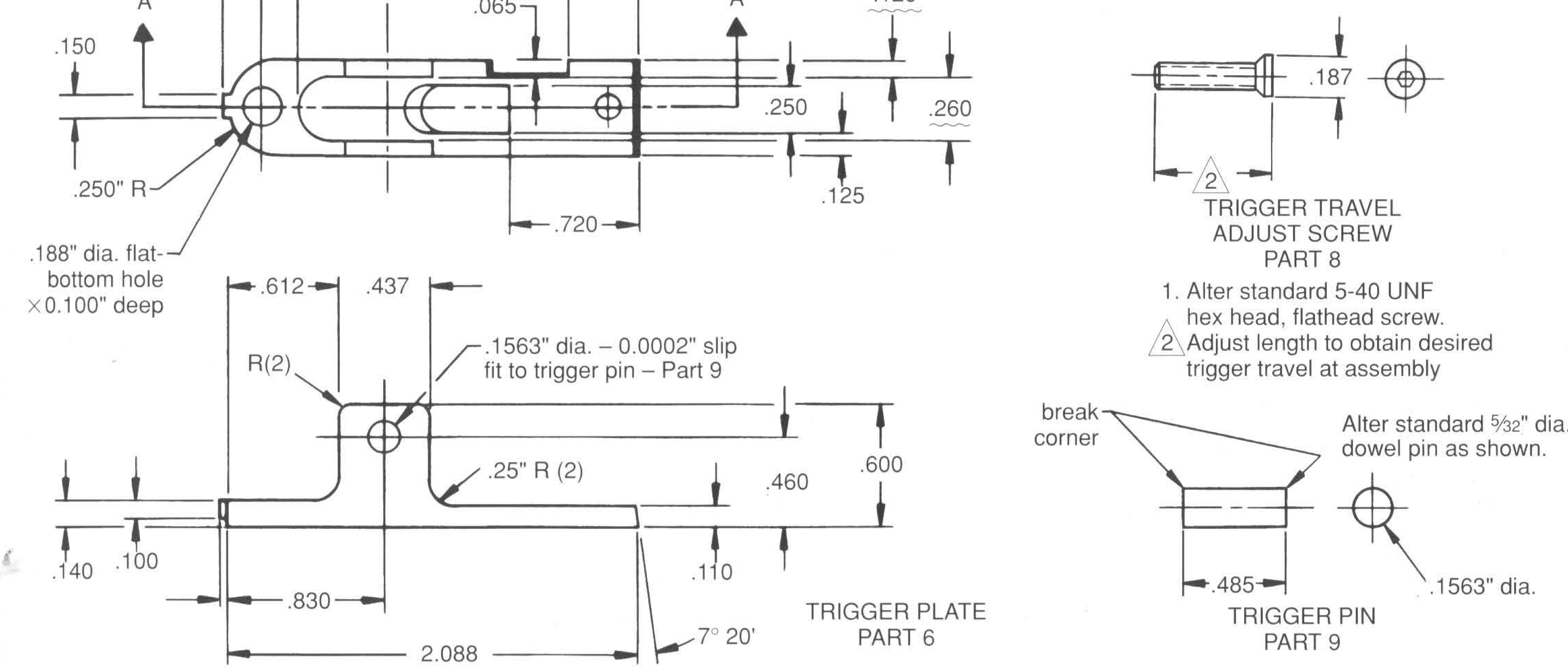
To start, make an accurate measurement of the 0.500" wide (nominal) slot in the bottom of the receiver. If this width is 0.500/0.501", you can take the part out of a piece of 1/2" thick, type 0-1, ground flat-stock tool steel. Mill it to its overall length of 2.138" and then mill the 0.260" wide slot, holding the 0.425" dimension and keeping the slot centered.

Then lay out the side profile of the part and mill, holding the part upright in the vise. Mill the 0.600" height and the 0.612×0.140" dimensions, stopping the mill cuts at the 0.25" radius lines.

Likewise, mill the rear part of the profile, holding the 0.110" and 0.437" dimensions. Again stop the milling cuts just short of the 0.25" radius lines. Take the part from the vise, deburr, and file the 0.25" radii to shape. Again, blue the bottom inside of the part and lay out the limit lines for the trigger slot. Using an edge finder, locate the center line of the part and mill the slot using a 1/4" diameter, two-flute end mill.

Remove the part from the vise and file the slot to its final shape and size. Again, grip the part in the vise and prepare to mill the 0.450" wide angle slot. Swivel the vise 7-1/3° in the proper orientation and mill the slot, holding the 0.325" dimension and the 0.450" width and the 0.065" depth. Then, clamp the part upright in the vise and, using an edge finder, locate the center line of the part and the center of



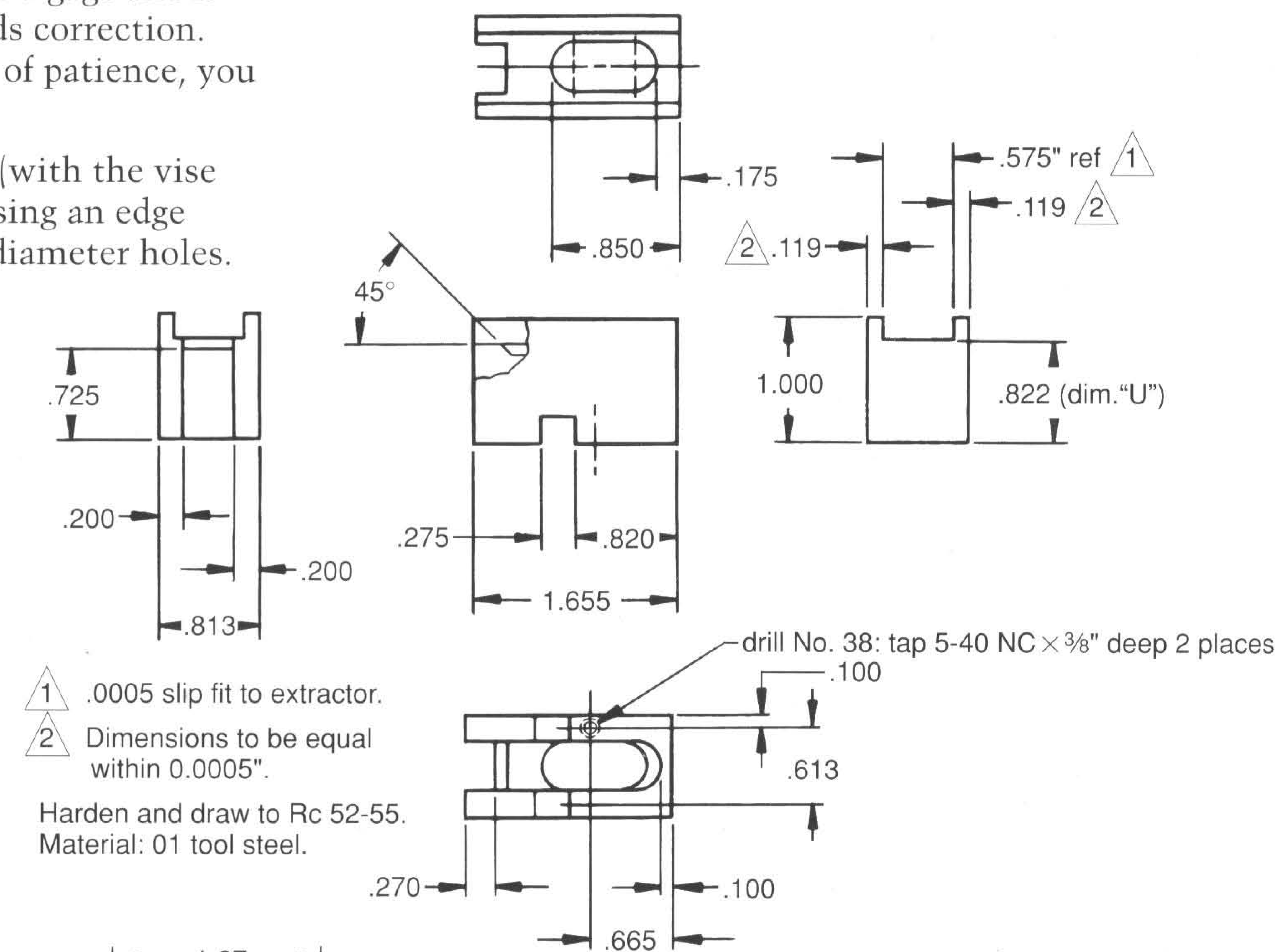



the 0.125" diameter hole. Center drill and drill a 0.1015" diameter hole through. Do not countersink the hole. This will be done later.

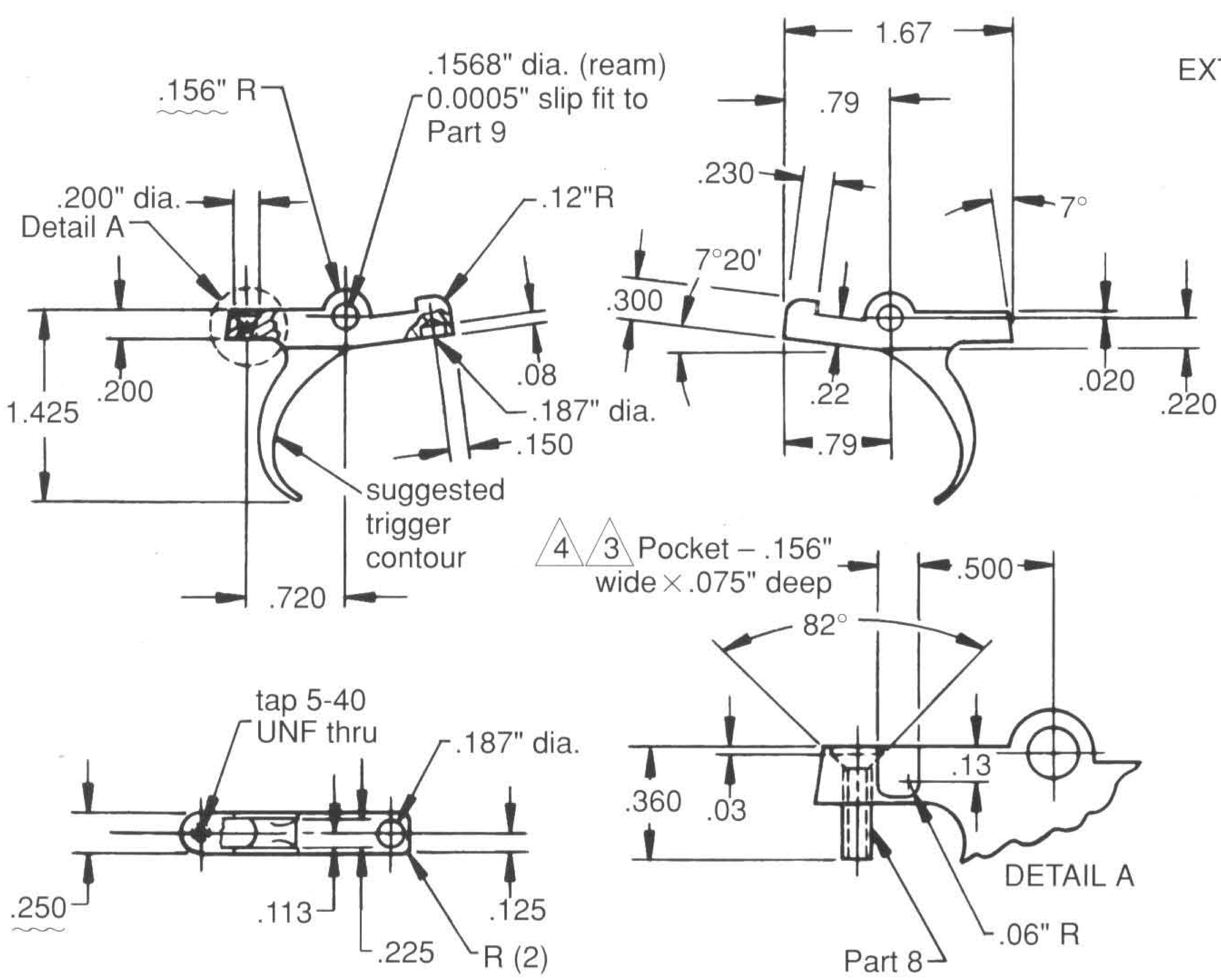
Now comes the part you may doubt can be done. But don't quit now, for you can successfully file the front end profile of the part. Blue the bottom of the trigger plate and using a 1/4" radius gage, scribe the rounded profile shown. Also scribe the 0.150" wide protrusion. Now, grasping a small pillar (safe edge) file, start working with confidence, filing to the lines. When you start to get close, use the breech block as a gage and it will be easy to see where the radius needs correction. With a minimum of luck but a quantity of patience, you will do a creditable job.

Finally, clamp the part in the vise again (with the vise square to the table, not swiveled), and using an edge finder, find the location for the 0.1563" diameter holes. Center drill, drill a No. 26 (0.147" diameter) hole and ream 0.1563" through. Now, get the breech block and fit the trigger plate in its slot. Transfer punch the 5-40 hole into the breech block, through the trigger plate hole. Drill a 0.1015" diameter × 1/4" deep hole in the breech block and tap 5-40 NC × 3/16" deep. Then drill and ream the 0.1015" diameter hole in the trigger plate to 0.125" diameter and countersink to 82° × 0.260" diameter.

Locate the position for the 0.188" diameter flat-bottomed, trigger spring pocket. Center punch the

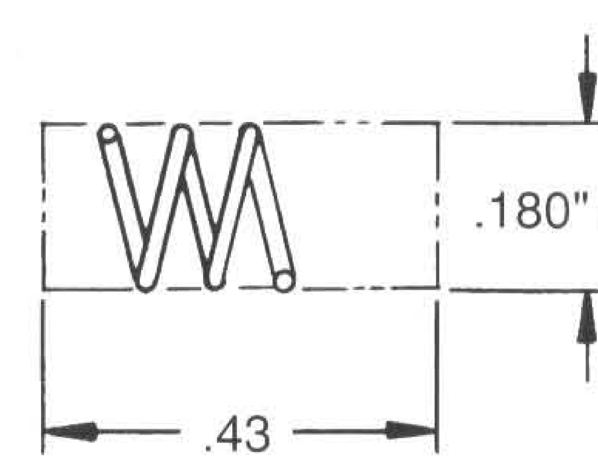



EXTRACTOR GUIDE
PART 4



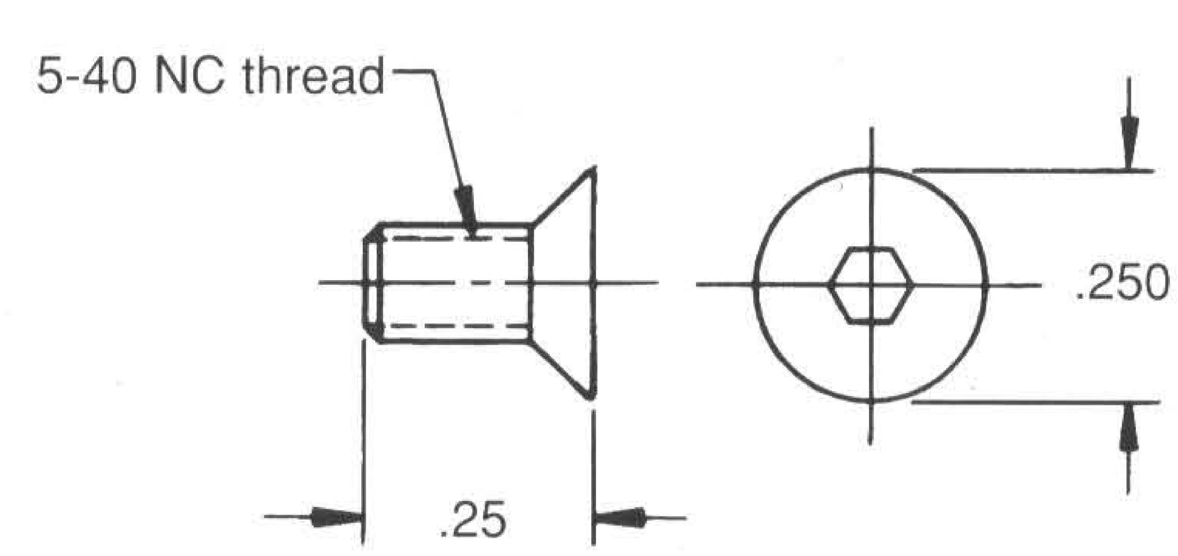

1. Materal: Type 0-1 tool steel.
2. Harden 62-65$R_C$. Do not draw.
3 Mill pocket with screw in place.
4 *Loctite* screw threads.

TRIGGER
PART 7




TRIGGER SPRING
PART 10

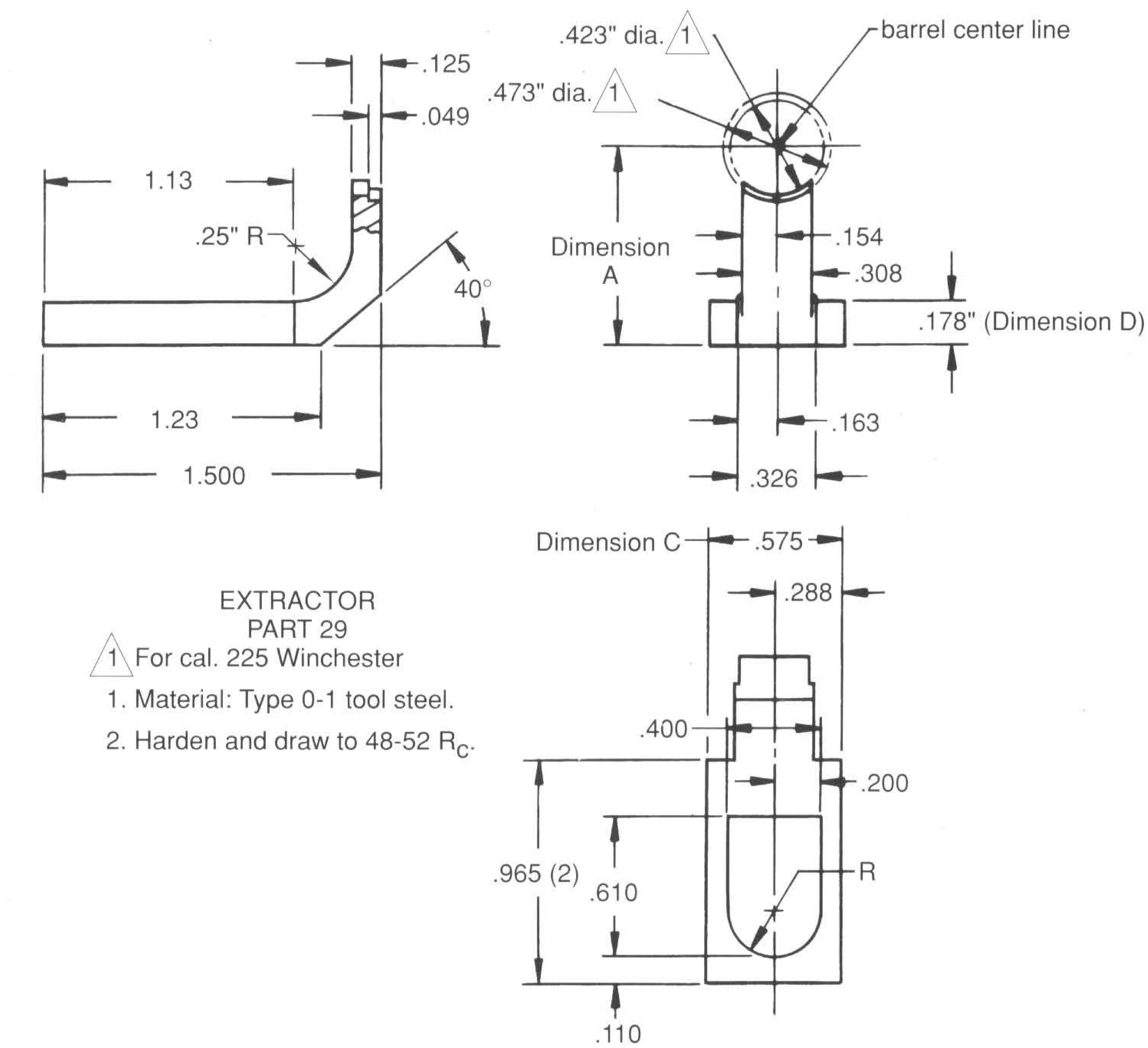
1. Material: 0.020" dia. steel spring wire.
2. Spring helix: 13 turns per inch.



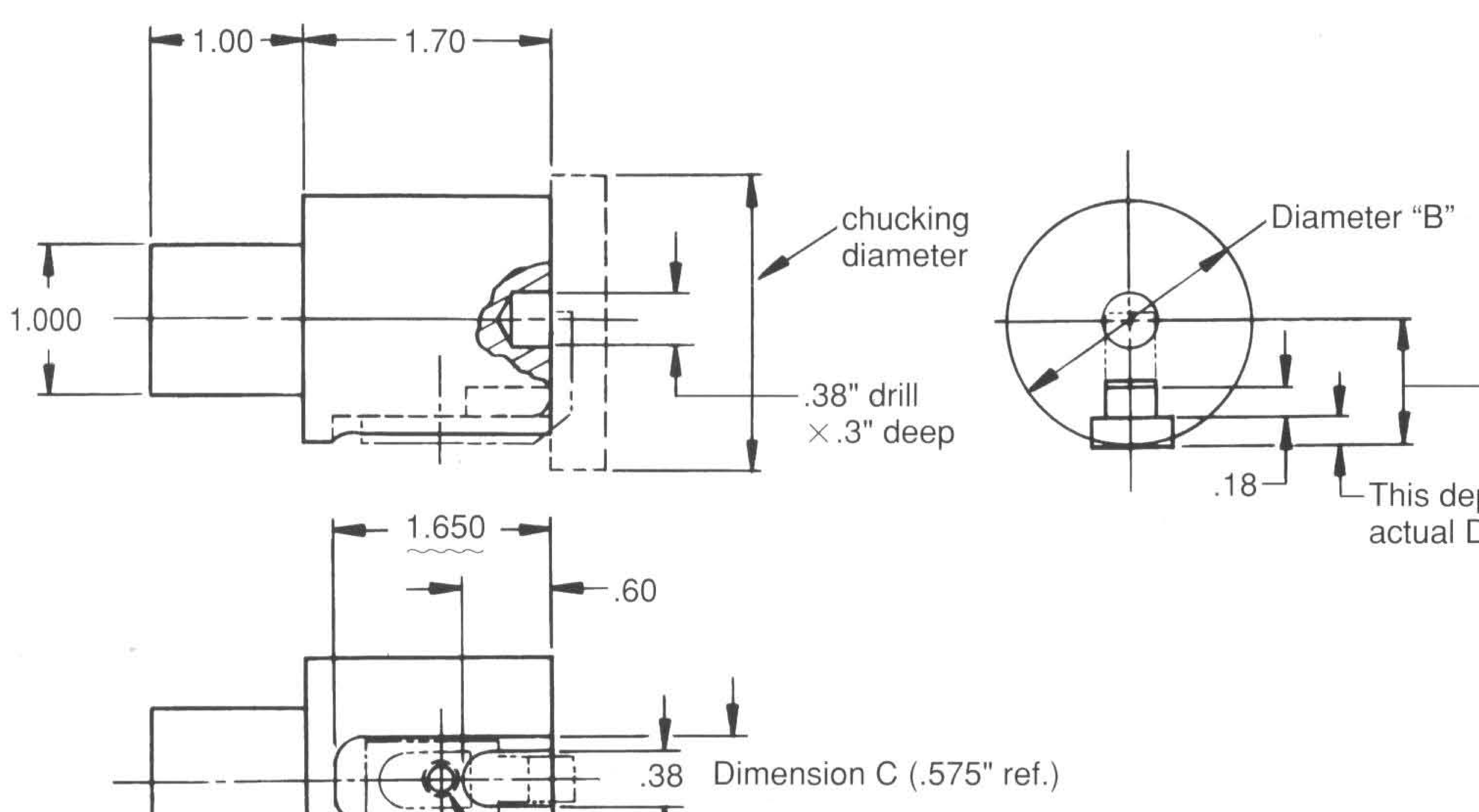

TRIGGER PLATE SCREW
PART 11

location and drill and flat drill the 0.188" diameter hole, making sure you don't drill too deep. Assemble the trigger plate to the breech block and, with the trigger plate screw in place, file the 7° 20' angle at the rear of the trigger plate to be flush with the breech block surface.

Next comes the trigger. Using the "high-tech" paper template method, establish the general shape of the trigger curvature. Then complete the layout of the upper trigger shape using regular layout technique, preferably with a vernier height gage. Band saw as close to the lines as you can. Center punch the trigger pin hole location, drill No. 26 (0.147" diameter) and ream to 0.1568" diameter. File the trigger to shape and then lay out the location for the trigger travel adjust screw (Part 8). Drill and countersink this hole. Install the trigger travel adjusting screw tightly and then lay out the location for the safety release pocket. Using a 1/8"




EXTRACTOR
PART 29
1 For cal. 225 Winchester
1. Material: Type 0-1 tool steel.
2. Harden and draw to 48-52 $R_C$.




EXTRACTOR MACHINING ARBOR
aluminum

Note: Turn dia. B and 1.000" dia. at the same setup to guarantee concentricity.

How to calculate Dimension A (extractor end view):

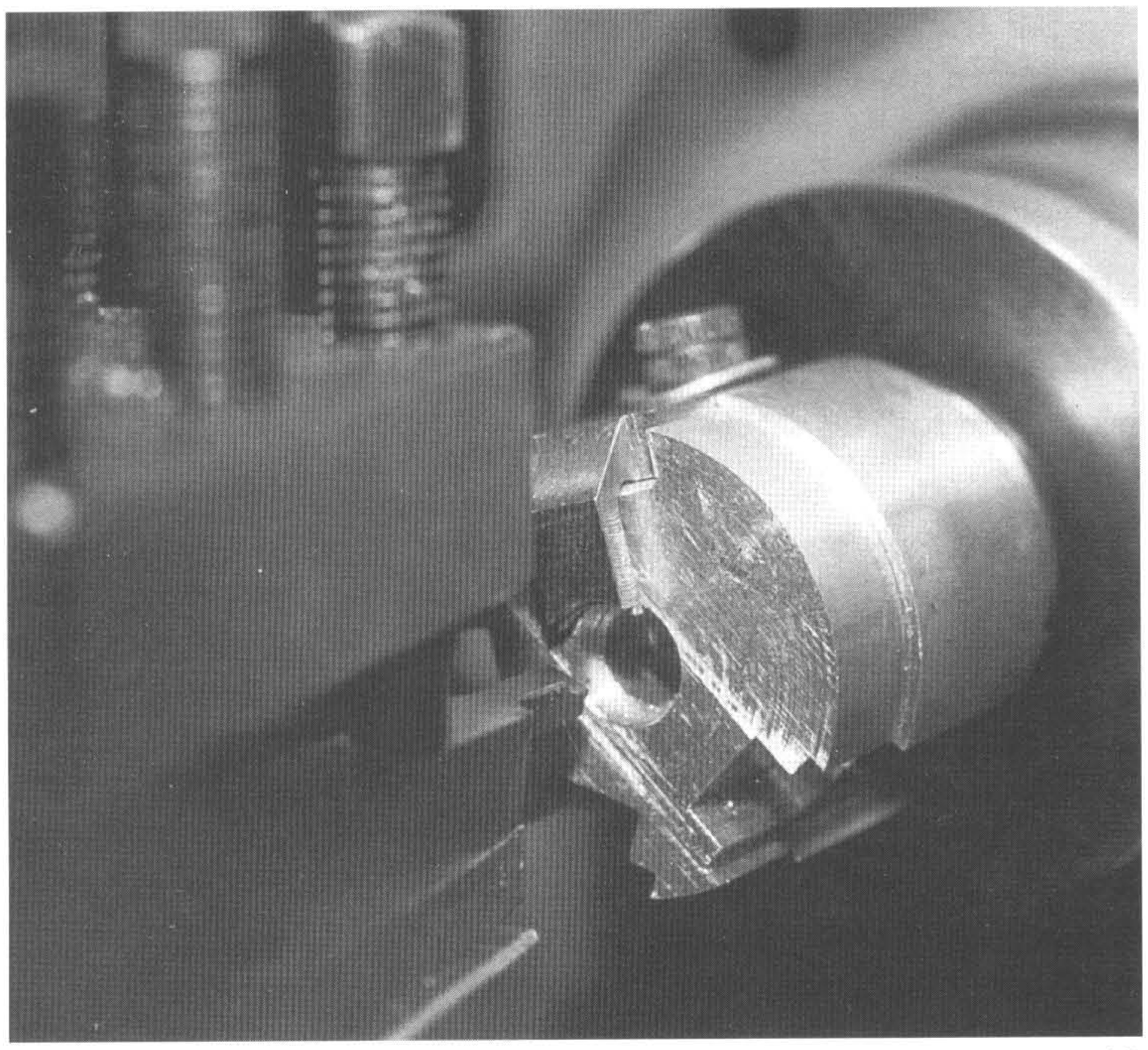
1. Measure your actural Dimension S (Part 1). Suppose that it measures .153".
2. Measure your actural Dimension T (Part 1). Suppose that it comes out 1.792".
3. Measure your actual Dimension U (Part 4). Suppose that it is .824".
4. Measure your actural dimension D (Part 29). Suppose that it is actually .176".

Then:

| | |
|---|---|
| Dimension T | 1.792 |
| minus Dimension S | – .153 |
| resultant | 1.639 |
| Minus Dimension U | – .824 |
| Now this is Dimension A | .815* |

Also: Dia. B = 2 × Dimension A
Dia. B is 2 × (.815) = 1.630*

5. Mill Dimension C slot to .001" slip fit to actual extractor dimension. Center the slot to Dia. B within .001" TIR.



12

diameter end mill, mill this pocket to the 0.075" depth.

Finally, drill the 0.187" diameter trigger spring anchor hole to its 0.08" depth. Then alter a standard 0.1562" diameter dowel pin to a length of 0.485" (trigger pin, Part 9). Another visit to your favorite hardware store spring assortment cabinet, with your caliper, should result in the selection of a dandy spring (Part 10), which when modified a bit completes the work (almost) on the trigger assembly. What remains is to trim the length of the trigger travel adjustment screw to give you the trigger travel you like. You have to have the entirely assembled breech block operational to do that.

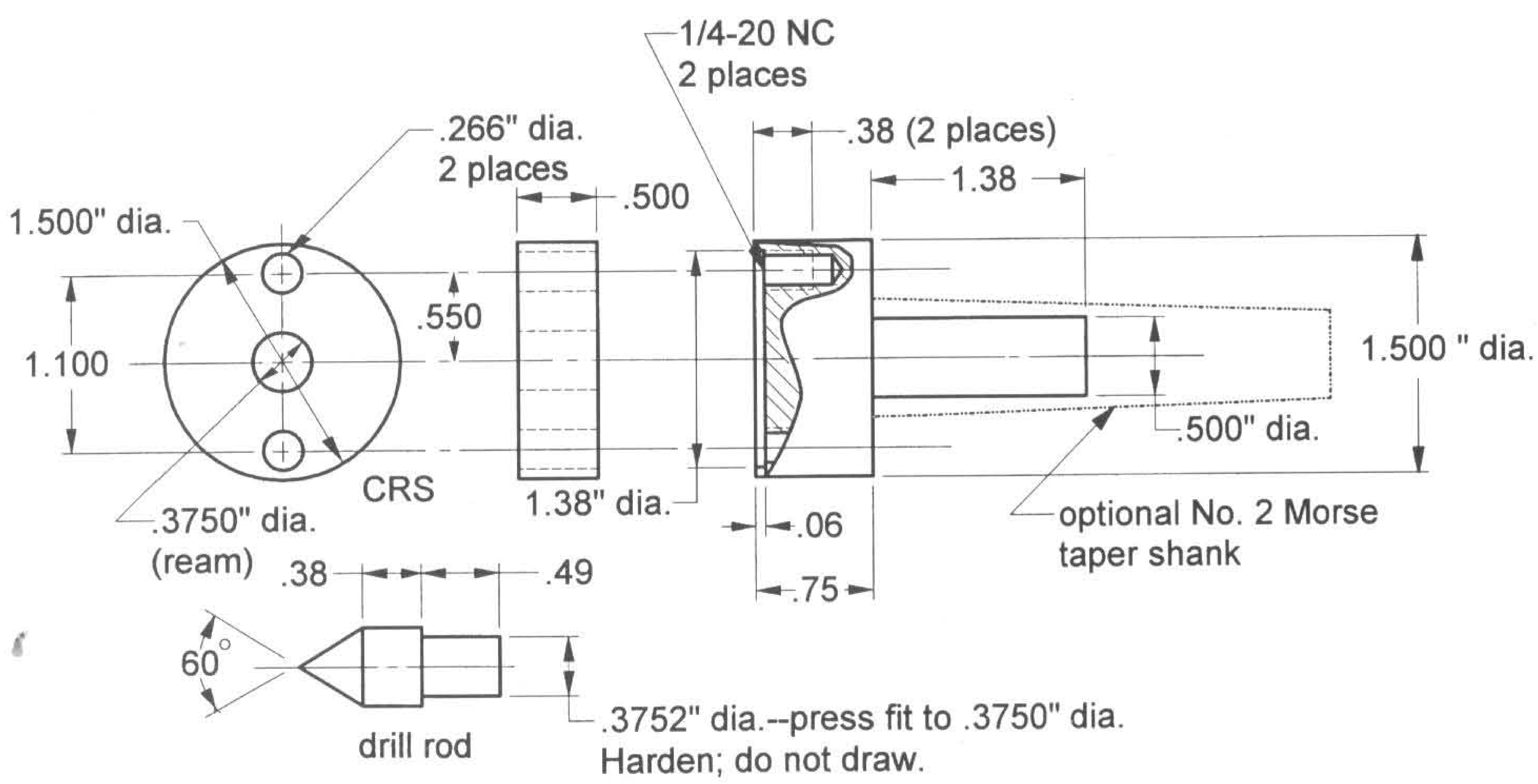
What remains to be done is to fabricate the extractor parts and the action floor plate. Indicate your milling vise to insure that the vise is lined up parallel to the table travel, because the extractor guide (Part 4) is an accurate, straightforward milling job. It must slip into the rectangular opening in the front of the receiver block, so measure as well as you can the dimensions you machined into your receiver and fit the extractor guide block into that outline. Carefully center the 0.575" (REF) dimensions in the center of the block. The openings in the bottom of the guide provide clearance for the motion of the finger lever, as does the file-finished 45° angle shown in the breakaway section. Do not drill and tap the 5-40 NF holes shown in the bottom of the block at this time. They will be done later. The cross milled 0.275" wide slot provides clearance for the 0.250" diameter cross pin.

Now is the time to make the extractor (Part 29). The machining, up to this time, emphasized keeping many features symmetrical to the receiver center line. This was done to insure that the extractor center line would coincide closely with the center line of the barrel bore. The same requirement holds for the extractor. The extractor is not a difficult part to make, but it's sort of like wrestling alligators. You should take the right approach. This part is typical of many gun parts, in that it's a little difficult to clamp it while machining. But, using the "drill vise held in the mill vise" trick, you should be able to make out, if you proceed cautiously. One word of warning; don't attempt to mill the 0.25" radius shown. It's only a clearance feature, so file it nicely in place. Also, the 0.400" wide slot is shown to have a flat end. The overall distance of this flat from the end of the part is 0.720". Hold that dimension, as the flat surface contacts the camming surface on the finger lever, which controls the distance the fired case is pulled from the chamber.

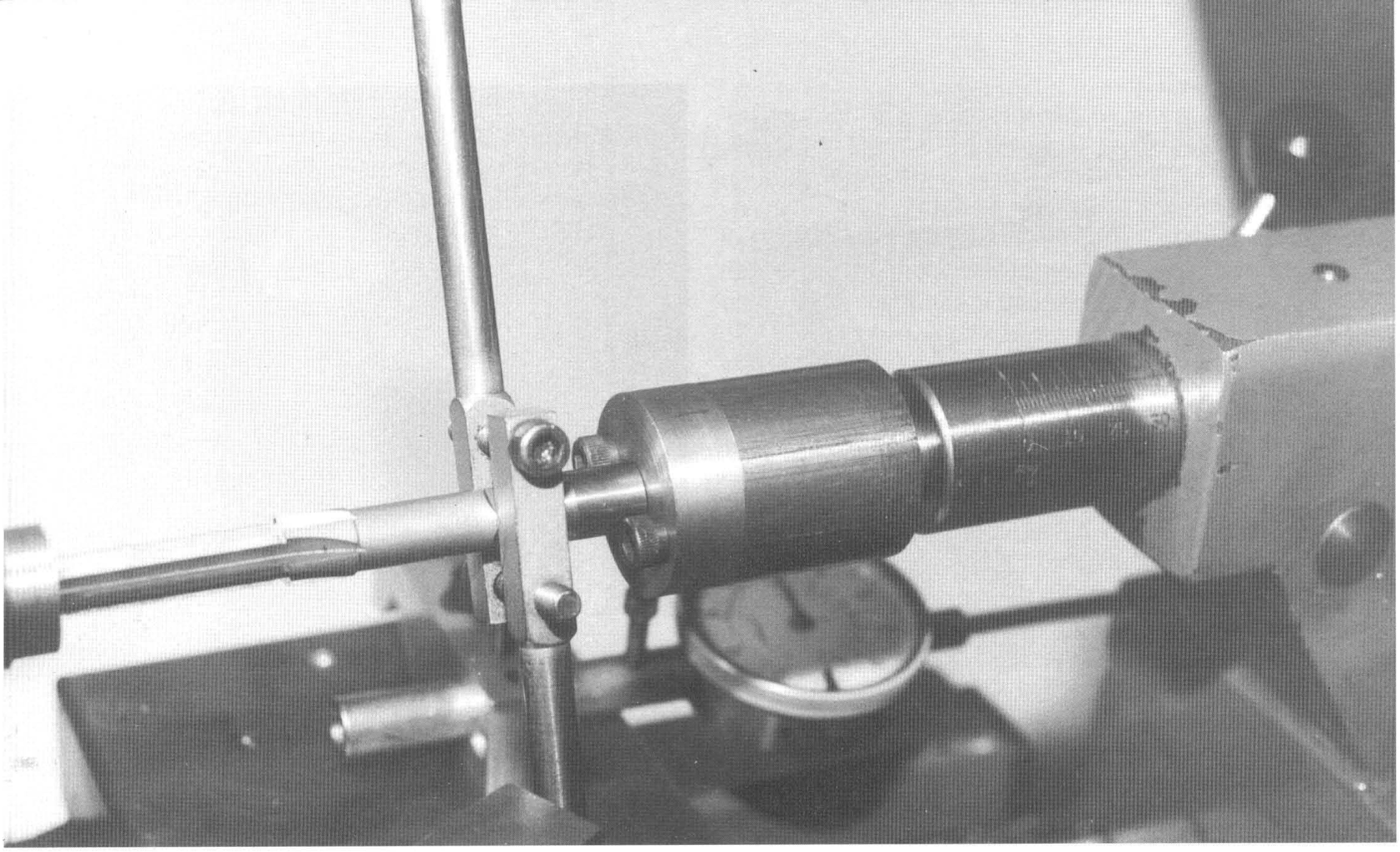
Now, how is the geometry of the extractor lip put into the exact place in the chamber mouth of the barrel, to function properly? On the detail drawing of the extractor, there is a considerable amount of printed instruction. This instruction tells you exactly how to construct the extractor holding fixture you need to machine the extractor lip feature, and how to make sure the dimension (A) will place the extractor lip at the correct location relative to the barrel bore. You can machine this feature into the extractor, using the setup in Photo 12 to finish the part, but to try out the extractor, you have to do some work on your stub barrel. I had promised earlier that you would learn how to chamber your stub barrel and cut the extractor slot. Now is the time to acquire that expertise.

If you haven't ordered your chambering reamer and chamber gages, do it now. you will need a finishing reamer in your chosen caliber, and two chamber gages, the "go" gage and the "no-go" gage. As you aren't chambering a quantity of barrels, you won't need a roughing reamer.

The way the chambering process is started is to get the axis of the bore dead on the spindle axis. This usually dictates the use of the four-jaw chuck, with a snug-fitting pin pushed into the barrel bore. Indicate the rotational position of the pin as "dead-



ADJUSTABLE CENTER TOOL


13

nothing" perfect as you can get it. There is probably no completely satisfactory way to machine the chamber in a barrel without duplicating an arms maker's equipment and process. Having (usually) only a lathe to work with, the gunsmith or amateur must improvise to some degree. My own improvisation, shown in Photo 13, reflects my experience and preference, but is not presented as an ultimate solution to the chambering problem.

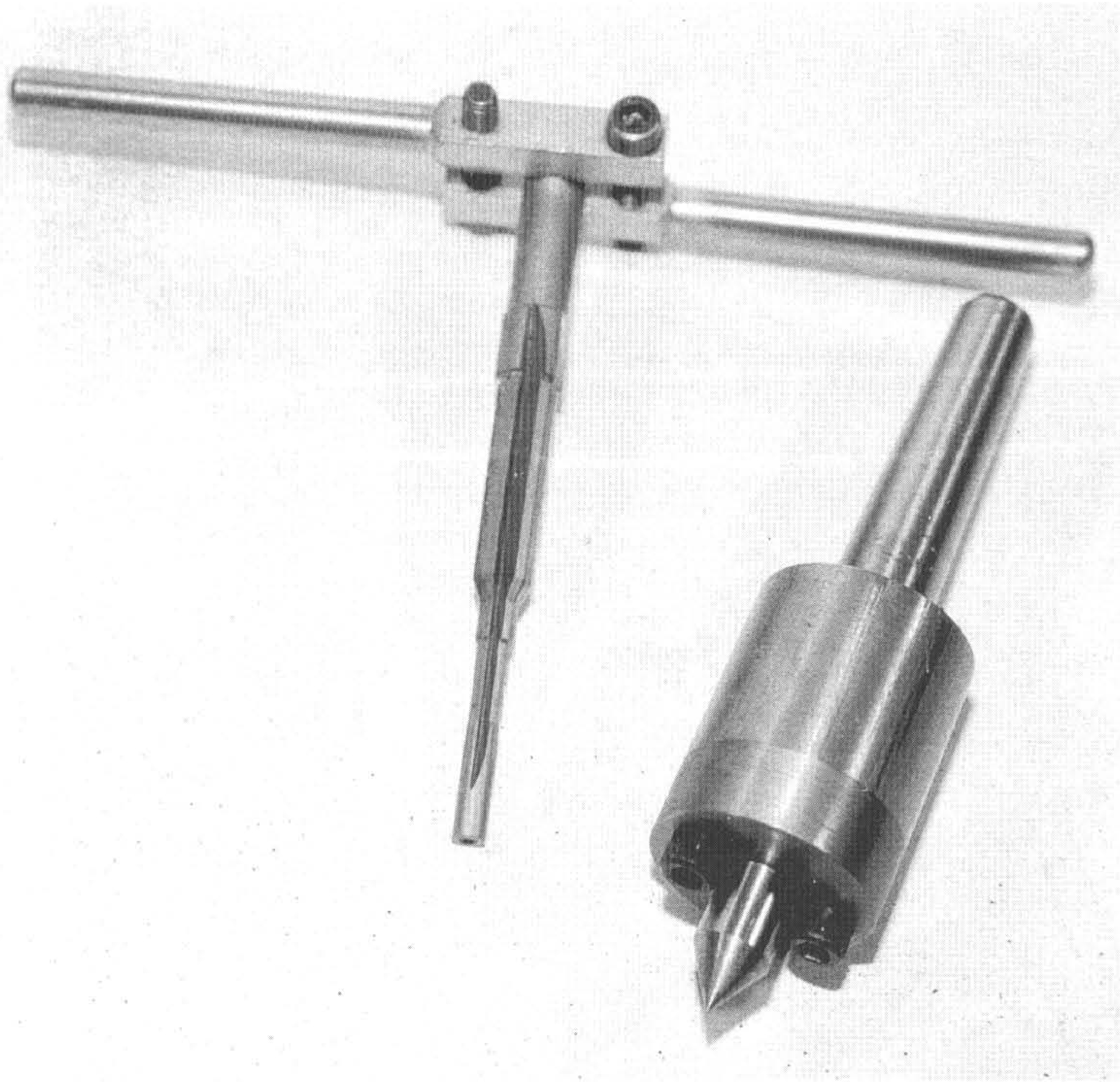
I will call your attention to two unusual features of my setup. The first (at right in Photo 14) is a tool that is installed in the tailstock quill. This tool is an adaptation of a toolholder in common use in screw machine and turret lathe setups. It is an "adjustable toolholder" and, in its original form, is used to hold a drill or reamer to produce a hole on the center line of a rotating workpiece. It is necessary, because, in well-used turret-type machines, the turret hole (which holds the cutting tool) may not index precisely aligned with the spindle axis. This tool lets the machinist adjust the position of the drill or reamer so it does line up with the spindle axis.

My adaptation is to make the tool with a 60° male center instead of the usual hole that accepts the drill and drill bushing. The reason for this, and for the long explanation, is that many lathes, including my own, have a tailstock axis vertically displaced from the spindle axis by as much as 0.004". This is no big concern to the machine manufacturer because, in a turning operation on a 1.000" diameter shaft, it results in an undetectable (for you and me) taper of only 32 millionths of an inch. But when you are using a chambering reamer, you want it right on the spindle axis, not 0.004" above or below. With the chambering tool off axis that much, it binds in the tapered hole it is cutting and is difficult to remove when you have to take it out of the hole to use your chamber "go" or "no-go" gage. Besides, you get a more accurate chamber, with no "bell mouth" and there's no gage to check for that.

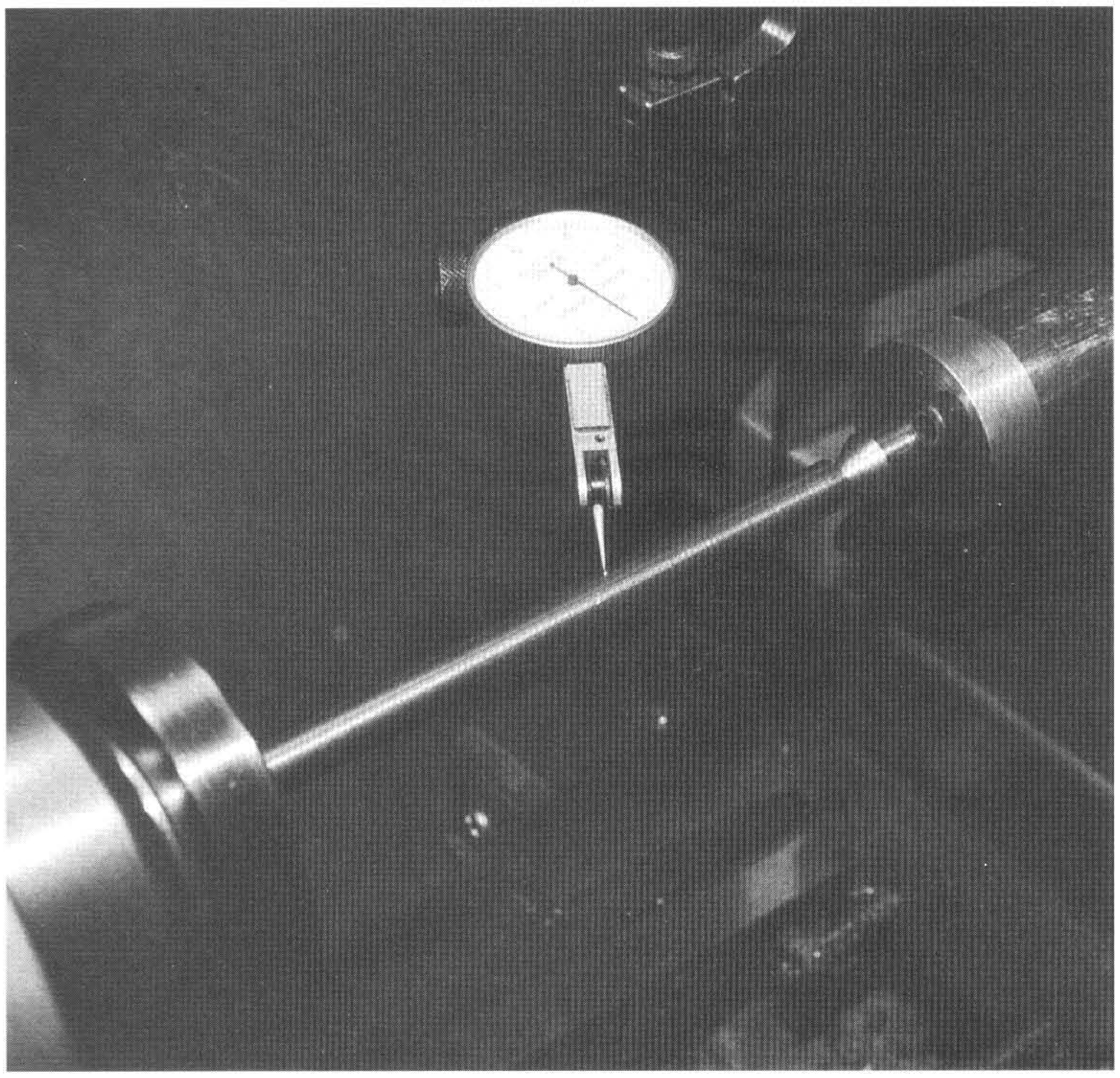
I set up the center line of the adjustable center (Photo 15) using an accurately centered, 1/2" diameter piece of drill rod, 6.0" long and setting it between centers and then indicating along its top and side to measure the tailstock center misalignment. It's then a simple matter to bump the movable center head of the tool to get it exactly on the spindle axis and lock it down tight. My tool uses a No. 2 Morse taper shank. Your tool, if you are forced to make one, could have a straight shank and be used in a drill chuck, but with the understanding that the adjustable holder be butted up tight against solid metal in the drill chuck, so the shank of the holder can't slide backward in the chuck. You need a lot of pressure to feed a reamer like this into solid metal.

You must remove the reamer from the chamber fairly frequently to clear chips and to use the chamber gages. You use your depth mike in conjunction with the "go" gage in this operation to determine how much deeper you must feed the reamer to get the right chamber depth. To do this, you are feeding the reamer with the tailstock screw, watching the micrometer collar as you go. When it is necessary to stop, I lock the tailstock quill clamp and move the entire tailstock to the rear. This is where the dial indicator comes in that you see mounted on the lathe bed in Photo 13.

At the start of the chambering operation that indicator is "zeroed" out. Then, when it's necessary to get the



14



15

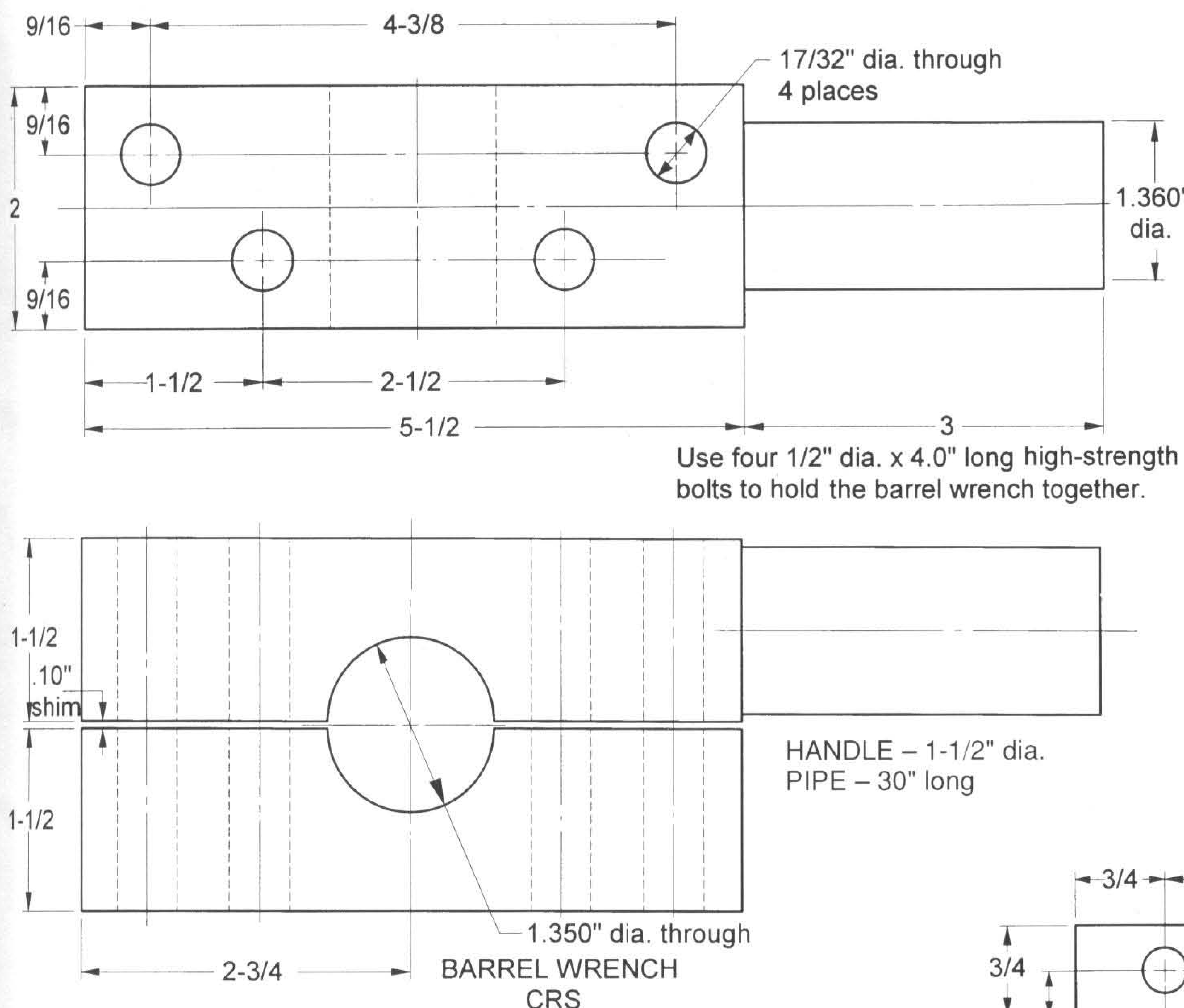
reamer back into its exact stopping location, you just move the whole tailstock back to the "zero" indicator reading. Sometimes you have to shove hard because there is some spring in the setup, but you can get it back. The picture of the setup shows how the adjustable center engages the center hole in the reamer, with the tap holder keeping the reamer from turning.

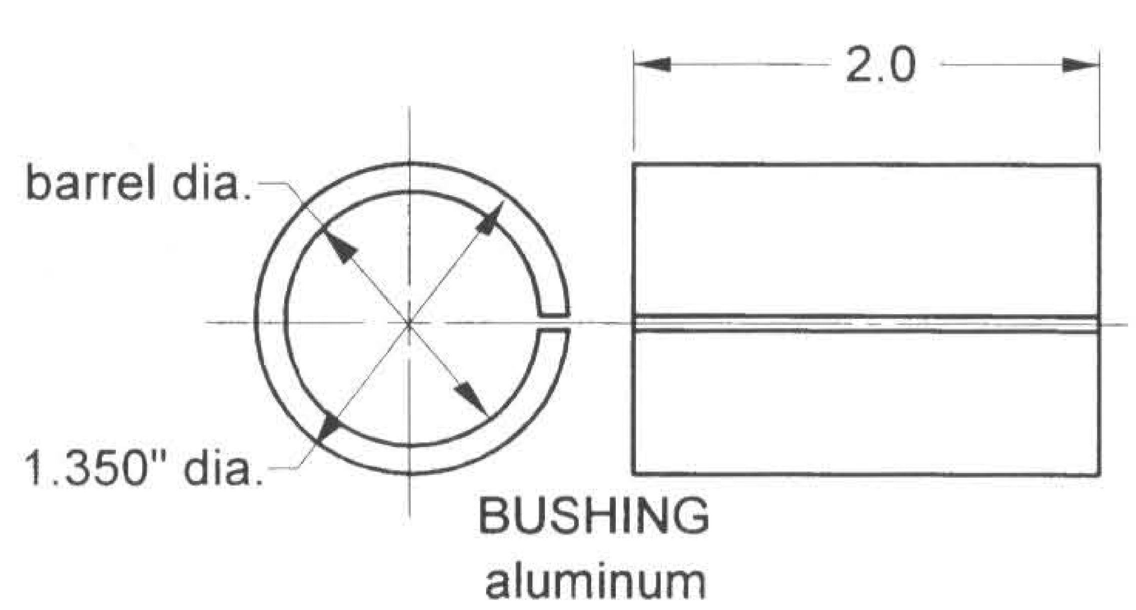
I hope the foregoing preparation and explanation will help make it possible for you to machine your chamber on the axis of the bore and to a depth such that the "go" gage is exactly flush to the chamber mouth face of the barrel. When I do the actual chamber machining, my spindle speed is about 120 rpm, and I use plentiful amounts of a good cutting fluid, such as *Tapmatic* (for steel). I can't pose as an expert, but in using this process and setup, I haven't lost a barrel yet. In fact, it's awfully hard to scrap a barrel, for if you do manage to go a little deep with the reamer and are dissatisfied with your results, you can take a few thousandths of stock off the barrel face and then remove a similar amount from the stopping shoulder on the barrel. So, this whole operation, besides being educational, turns out to be quite safe.

For those of you who possess copies, in the assembly drawing, the drawing published in the original series of the trigger (Part 7) had a slightly different design from the one you see in this chapter. Steve Stumpf, of Stumpf Ordnance, pointed out that the trigger sear angle was potentially dangerous. The three rifles I have previously built were all made to the earlier design (the one in the assembly drawing). All the rifles have performed with no problems, as I would expect, since what we are talking about is a small design point. Involved is a number which is the cosine of a 7.333° angle, which is 0.99182. Steve points out that this number should be 1.0000 and he is right. The small difference of .00818 allows a force of about .25 lbs. to act so as to make the trigger discharge of its own accord, which is definitely not desirable. *But* there is also a friction force acting on the trigger, which must be overcome before the trigger can be moved, and this friction force is at least 3.0 lbs. (using a coefficient of friction of 0.10 – much smaller than the commonly accepted value of 0.167), so the trigger cannot move of its own volition. The measured trigger pull force of all my actions has been right around 2-3/4 lbs., so I don't think my mathematics or mechanical assumptions are that far wrong. But from a theoretical standpoint, I agree that Steve is entirely correct. You will note that the striker is also involved, but corrections have already been made as shown on page 27. Thus, we can be satisfied that we are in accord with the most rigorous mechanical and mathematical thinking.

Now that you have successfully chambered your stub barrel, the next thing you have to do is cut the extractor slot in the barrel face. This isn't hard to do, but it takes some careful measuring and machining. First of all, though, you have to learn how to install your stub barrel to the receiver. For this, you need a tool known as a barrel wrench.

In this operation, you are going to screw the stub barrel tightly into place. "How tight is tight?" did you ask? Well, I have never seen any published data on the subject, but I do have some experience. After WW II ended, I had occasion to rechamber a number of 8mm German army rifles and, of course, I had to remove the barrels. I built a barrel wrench, somewhat like the one you will use, with



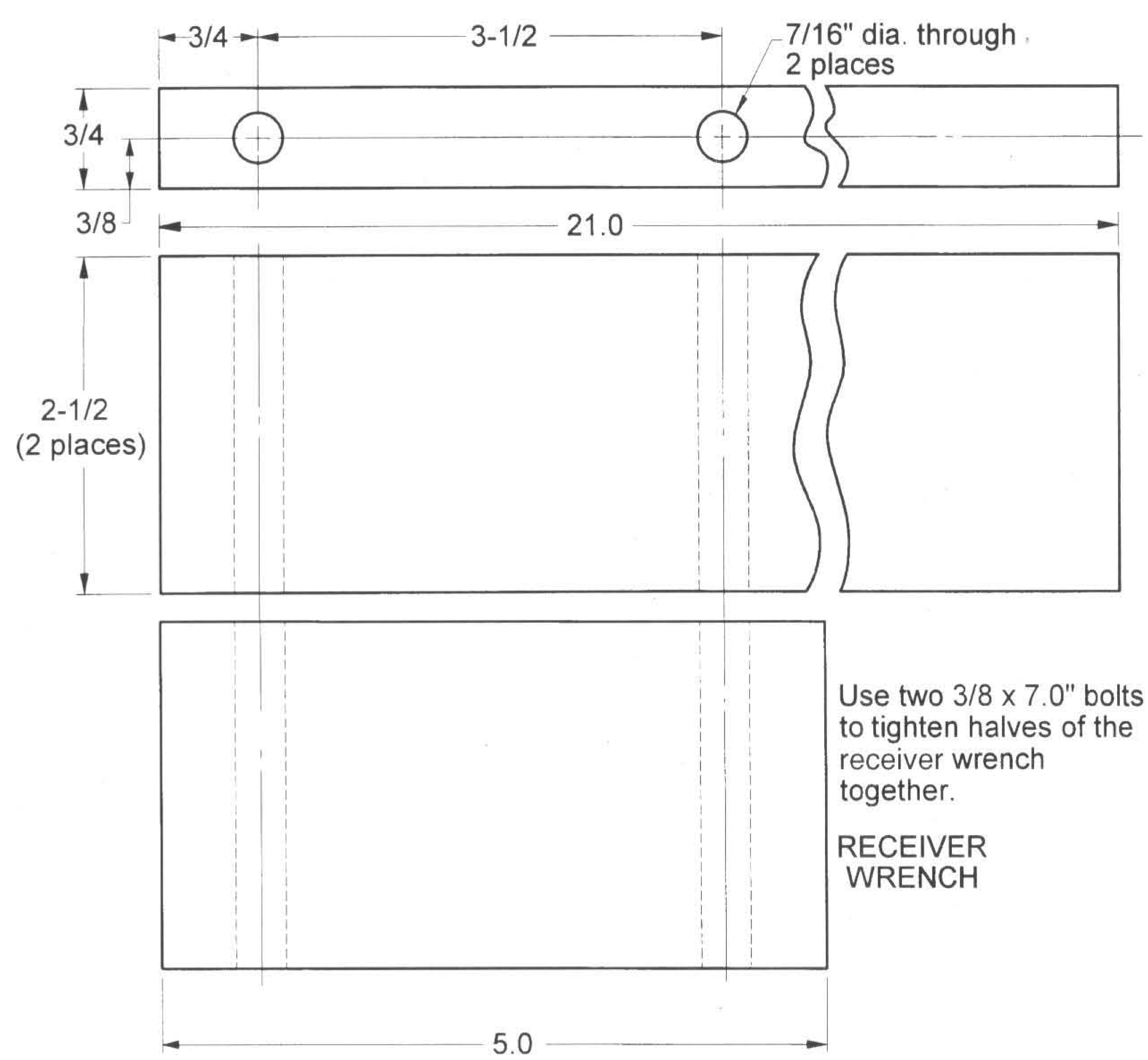



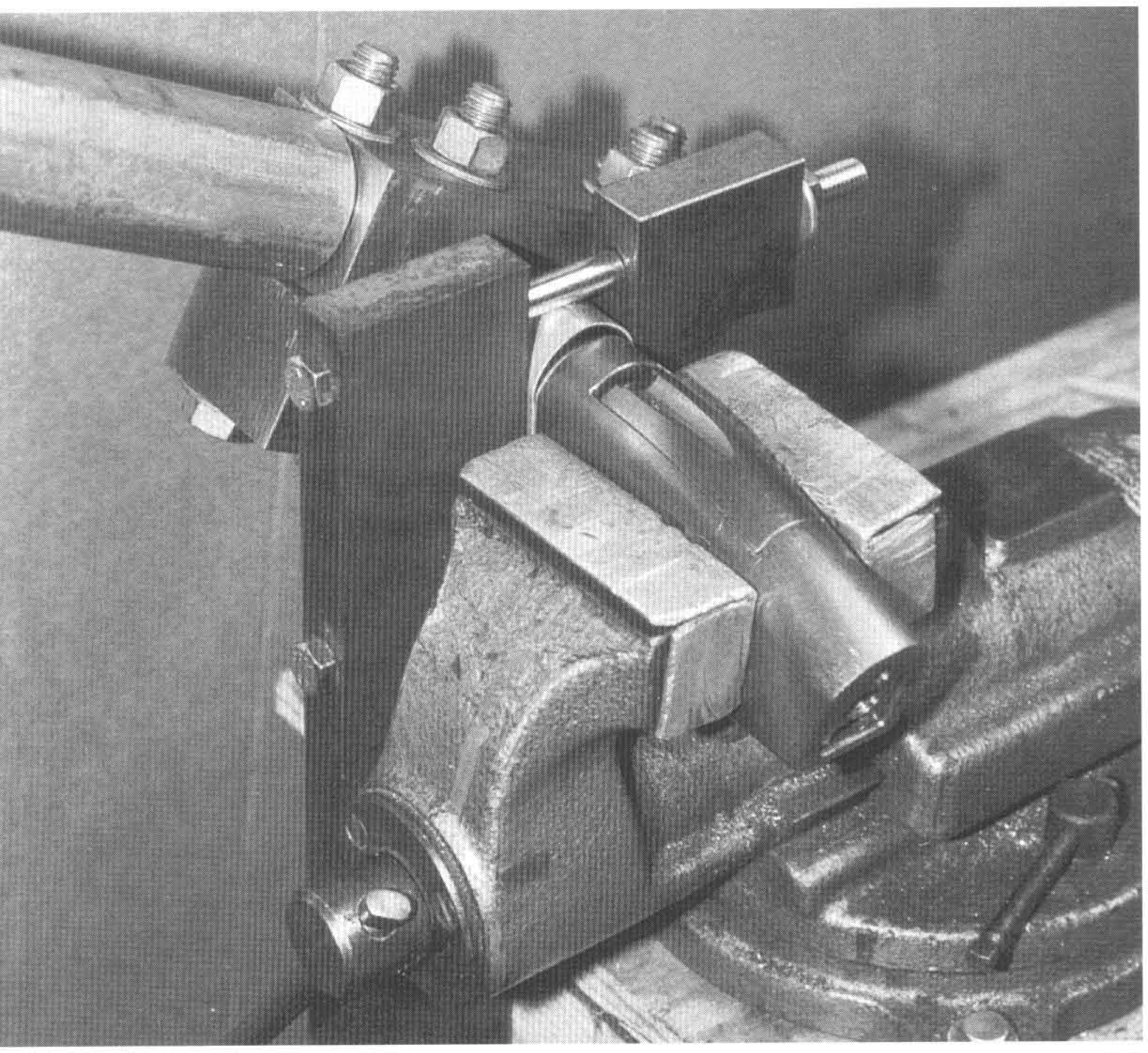

a wrench handle that was a piece of 1-1/2" diameter pipe about 30" long. I weighed about 180 lbs. and I had to chin myself to get those barrels to break loose! For your information, that's 450 ft/lbs of torque. I have read of other gunsmiths who allowed for 0.001" of barrel shank stretching during barrel installation. I believe their experience. I do not think, however, it's necessary to use 450 ft/lbs of torque. I usually screw the barrels in with about 300 ft/lbs of torque and find that to be plenty.

Take a look at the barrel wrench drawings and also see Photo 16. That will tell you all you need to know about making and using this tool. In making your barrel wrench setup, install the breech block in the receiver before you clamp the receiver in the vise to keep from distorting the receiver side walls. Screw the barrel in, using your best judgment as to when you have exerted 300 ft/lbs of torque. Now, remove the barrel wrench and take the receiver and barrel assembly out of the vise. It's time to consider how you are to cut the extractor slot in the barrel face.

Probably the most difficult task facing you is to establish the vertical orientation required of the extractor slot, relative to the barrel center line. What I do is this. First, I blue the barrel face. Then I find a 3/16" thick piece of stock (I always have 3/16" tool bits lying around) and, laying the shim (tool bit?) on the receiver side wall and up against the barrel face, I scribe a line vertically on the barrel face. Using the barrel wrench again, I remove the barrel from the receiver. Now, I get a length of 3/16" diameter rod about 3/4" longer than the stub barrel, and I cut a 10-32 thread on both ends for about a 1/2" length of thread.

Next, get a 4" length of light stock (1/8" thick is fine) × 1/2" wide with one straight edge. Now, at the center of the piece and 7/32" from the straight edged side, drill a 3/16" diameter hole. With the threaded rod down the stub barrel bore and using nuts and washers, fasten the straight edged piece to the barrel face, aligning the straight edge very carefully with the line that was scribed on the barrel face. Now, I make a milling



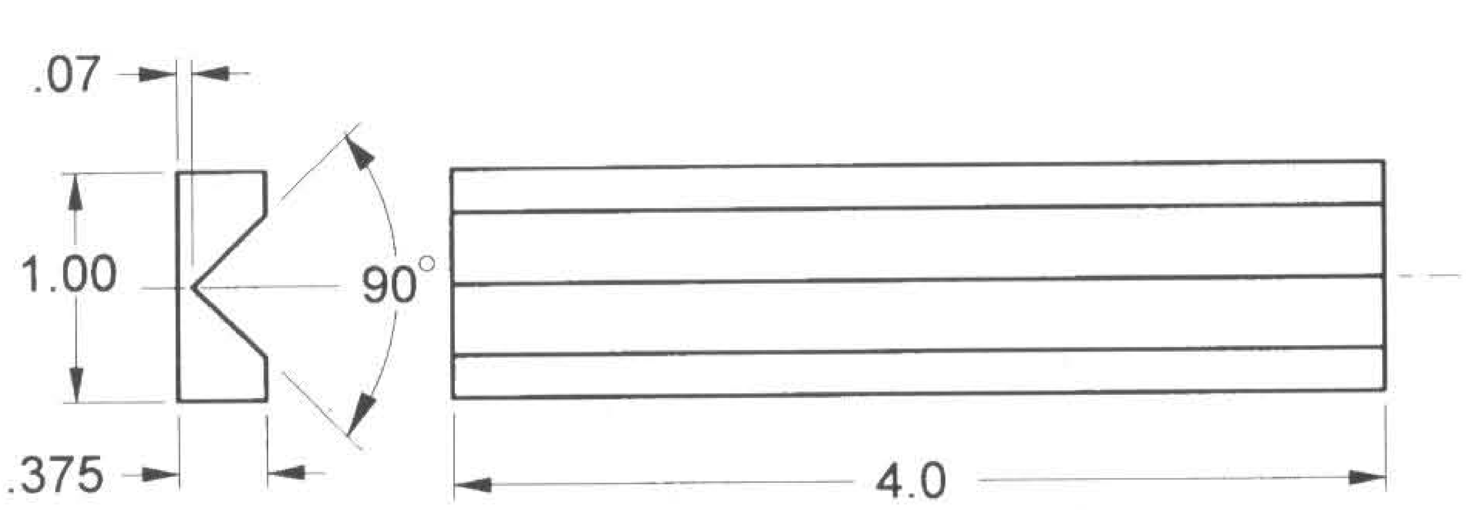


16

attachment setup on my lathe and carefully indicate it for proper alignment with the spindle axis.

Using the V-parallels (Photo 17) to align the barrel in the milling vise, I lightly clamp the stub barrel in the milling attachment, with the straight edge on the barrel mouth "eye-balled" into a horizontal position. Then, I set an indicator in the lathe spindle, and indicate the barrel axis parallel to the spindle center line and the straight edge on the barrel face (Photo 18) parallel to the cross slide travel. After tightening the milling vise screws, I recheck the workpiece alignments to make sure nothing moved. Then, I remove the straight edge apparatus from the bore and, using an edge finder, I pick up the center line of the barrel and, finally, am in a position to mill the extractor slot.

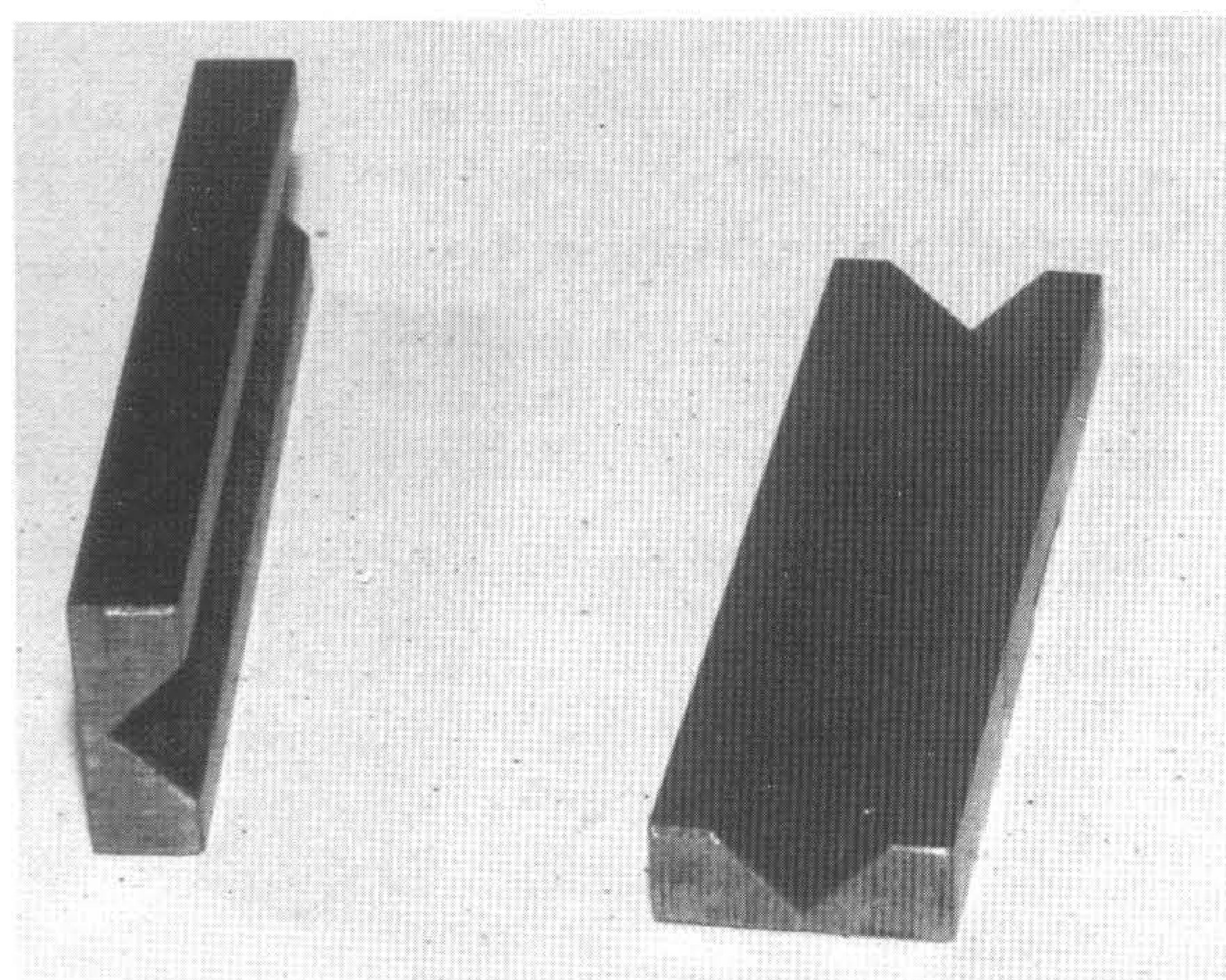
Installing a 5/16" diameter end mill in the spindle, I mill the extractor slot to the 0.125" depth required, but I mill only to a width of 0.323". The extractor lip width is called out to be 0.326" wide, but it is unlikely this dimension will be met exactly, nor is it likely that the extractor lip will be precisely centered about its center line. Therefore, there is a small amount of finishing stock left for judicious hand-filing when the stub barrel, the extractor guide and the extractor are assembled to the receiver.



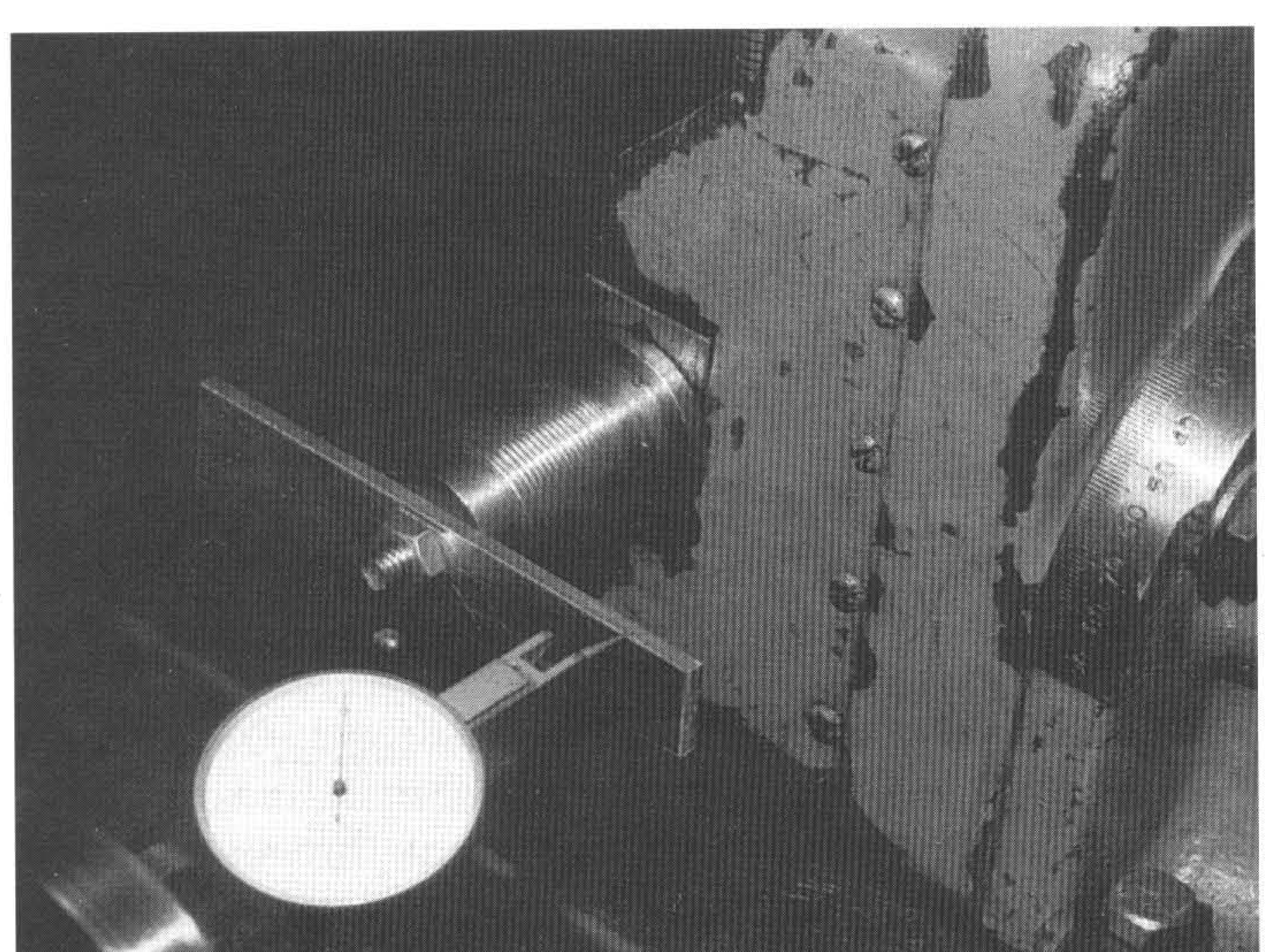

V-PARALLELS
CRS
2 required

Now, using the barrel wrench, prepare to install the barrel to the receiver. Slip the extractor guide into place along with the extractor, and install some blocking in place in the receiver slot, but leave finger room at the chamber mouth. Now, clamp the receiver in the vise and, with the barrel wrench, turn the barrel into place. The challenge is to position the extractor slot precisely so it will accept the extractor lip. Of course, the extractor is slightly oversize and must be file-finished to fit, so some very sharp-eyed inspection is required to determine where and how much metal is to be removed. Working carefully and, measuring closely, you will be successful.

Two small operations remain to be done on the breech block assembly. Strip the breech block to prepare it for machining. Set it in a drill press vise, with the striker sleeve bore parallel with the drill press spindle. Then regrind a 1/4" diameter drill to have a 60° included angle drill point, thinning the web sufficiently so it will be able to center in the 0.070" diameter, previously-drilled, firing pin hole. Countersink the firing pin hole to a diameter of 1/4" in the striker sleeve bore. Now, clean all the chips and reassemble the



17



18

breech block, including the "too long" firing pin. Blue the tip of the firing pin and then mark its protrusion length to be 0.050" in its outermost position. Disassemble the firing pin assembly and, in the lathe, shorten the firing pin to its marked length. Finally, form a nicely radiused ball nose end on the firing pin. Reassemble the firing pin parts to the breech block and the breech block is completed.

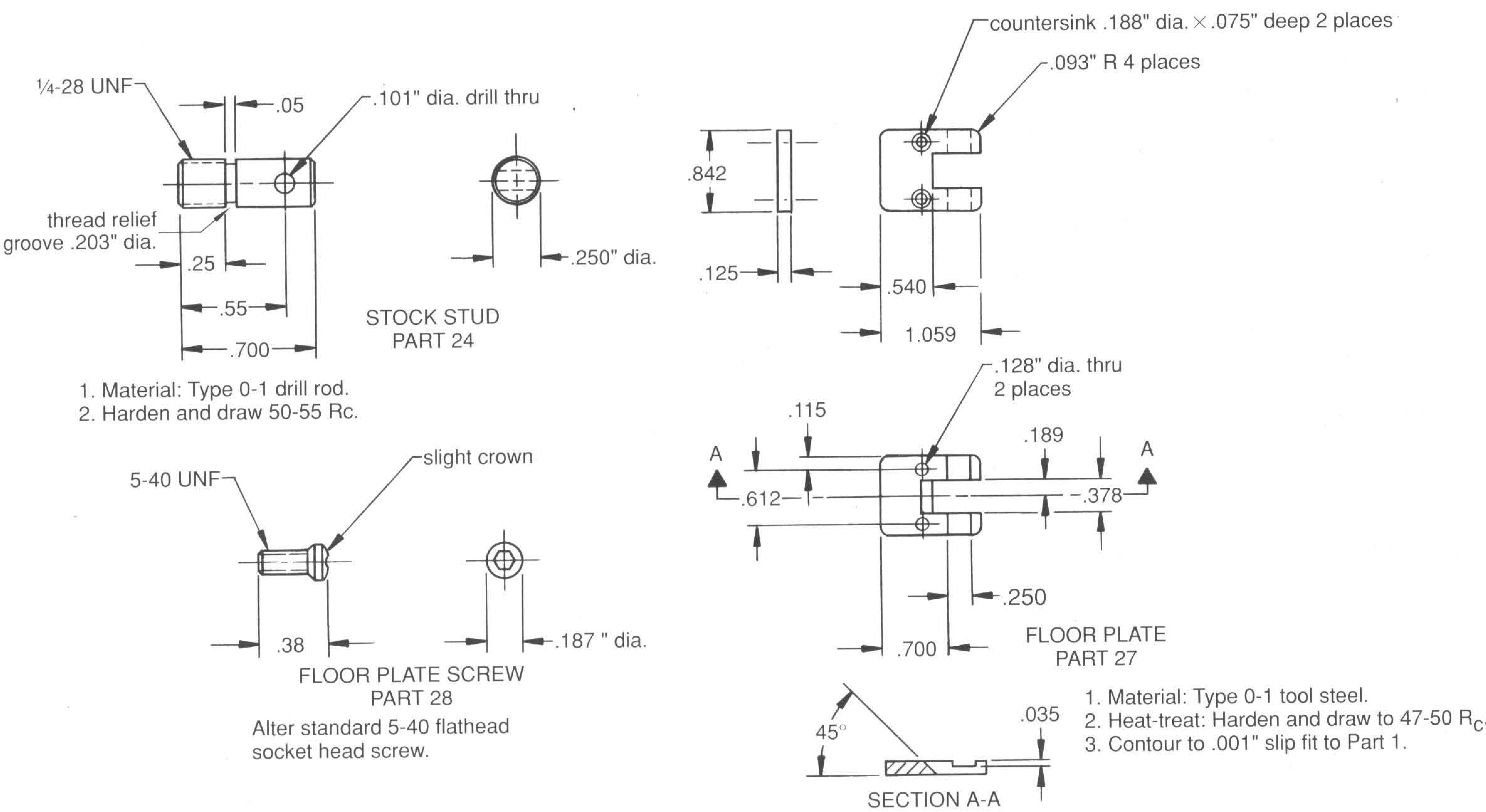
Only two details are left to be made before the action can be called complete. These are Parts 27 and 28, the floor plate and the floor plate screws. The floor plate requires some careful measuring, machining and filing, because it is a part that will contribute to the external appearance of the receiver. It must fit the opening in the bottom front of the receiver exactly, but this is a simple milling operation. It also has radiused corners and they must be hand-filed. If you still have the end mill you used to form the opening, make a micrometer check on its OD size. If it is close to 0.188" diameter, then blue the part, and using your radius gage, scribe 3/32" radius arcs on each of the four corners.

From here on in, it's fit and file. When the floor plate slips tightly into place, you can lay out and spot the 0.128" diameter holes. This is a milling machine job, using an edge finder. Locate and center drill the two holes, and then locate and mill the 0.035" deep × 0.250" wide clearance slot. In the drill press, countersink the two 0.128" diameter holes to 0.188" diameter and flat bottom drill to the 0.075" depth. Now, install the extractor guide to the receiver and put the temporary cross pin in the cross pin hole. Then slip the floor plate into its opening and transfer punch the location of the two 0.128" diameter holes in the floor plate into the extractor guide. Then disassemble the parts from the receiver, and drill and tap the extractor guide for the 5-40 NC screws, as called for on the detail drawing. Alter two flathead, socket head, 5-40 × 3/8" long screws as shown in the detail drawings, and the receiver parts are all completed.

Now, you can contemplate the problem of making the remaining parts that will ready the action for assembly into a rifle. Make the simple parts first. Turn, thread and cross drill the stock stud (Part 24) and lay it aside. Turn, chamfer, drill and countersink the stock bolt washer (Part 35) and lay it aside. Turn, thread and cross drill the stock bolt (Part 30). You will probably have to use a follower rest to support the workpiece while you are turning the 0.44" clearance diameter, but there should be no problem with that. The forearm support stud (Part 36) is another simple lathe part. Cut off and face the stud to length and thread the end 1/2-20 UNF, as shown, but do not drill the 0.250" diameter hole at this time. Later is better.

The next two parts to be considered, the receiver dovetail anchor (Part 31) and the forearm dovetail (Part 32), are best made when done together. The key features of both are the mating dovetails, and these should fit together snugly, with no looseness.

The forearm dovetail should be started first. It has a finished length of 1.790". This length should be left at about 2.000" to start, giving room to center drill the location for the diameter marked "barrel diameter + 0.150"." Do not locate the barrel clearance hole center. This portion of the part will be finished on location when

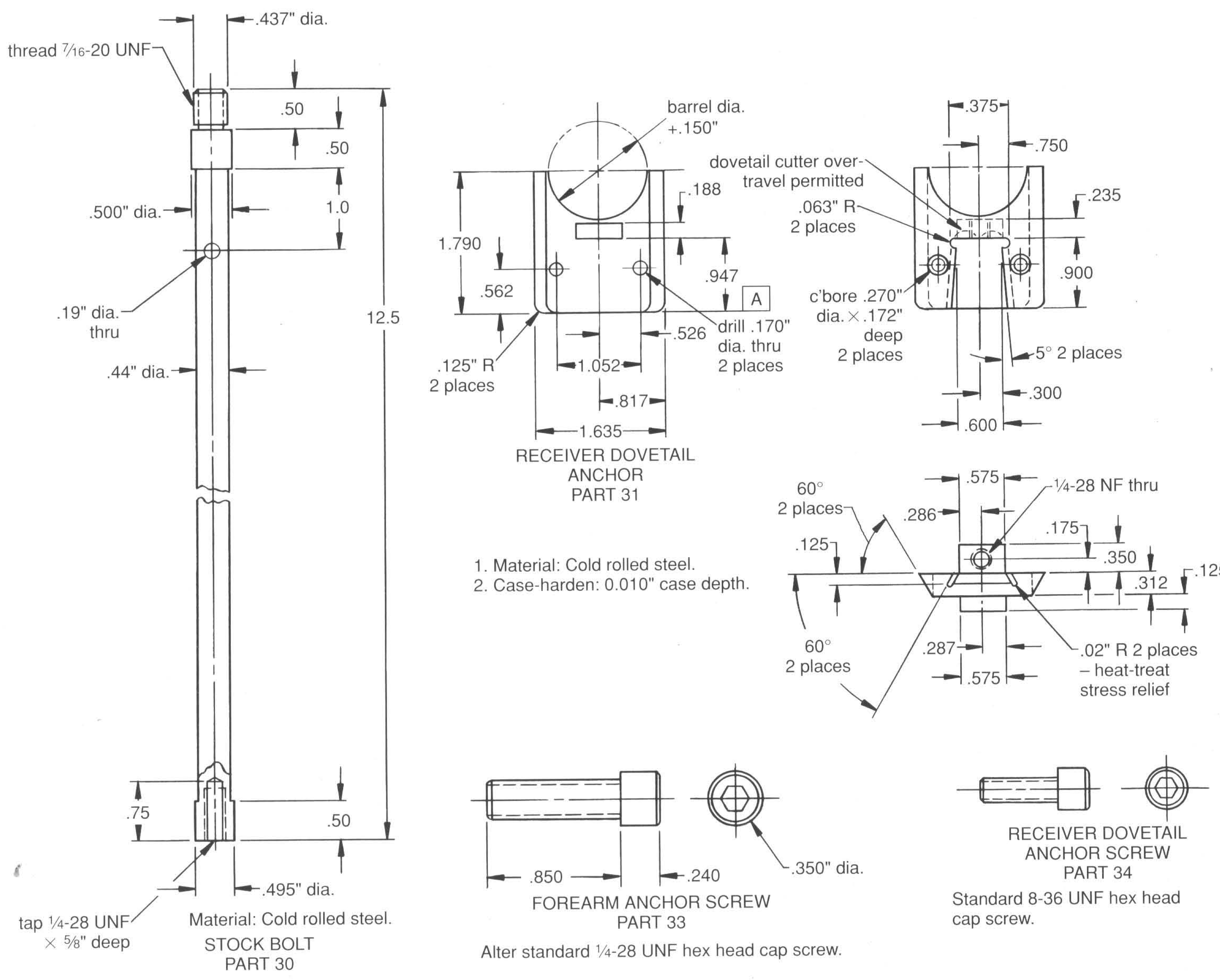


mated to the receiver dovetail anchor. The machining of the part is otherwise quite straightforward, except for the dovetail. This feature can best be machined using a 3/8" diameter dovetail cutter, with the milling vise swung 5° right and left of center. The stress relief groove shown at the sharp internal corner of the dovetail is filed in, using a knife-edge pattern Swiss jeweler's file.

The receiver dovetail anchor is similar to the forearm dovetail, but is anchored to the receiver front end and located by the 0.575" wide × 0.188" thick tongue, which fits into the end of the extractor guide slot. Again, the feature of central importance is the internal dovetail slot with the 10° included angle. The two rectangular tongues on each side of the part can be machined on location; the dovetail cut and the 1/4-28 NF threaded hole can also be finished. The two 0.170" diameter holes can be drilled and counterbored on location. The center location of the "barrel diameter + 0.150" diameter" hole can now be established and center drilled.

Now the two parts should be mated together and the 1/4-28 NF lock screw installed. The assembly can then be indicated coincidental to the spindle axis, when clamped securely to the faceplate setup, and the "barrel diameter + 0.150" diameter" bored concentrically in both parts. The assembly is then moved to the mill and the 1.790" dimension is finished on the receiver dovetail anchor and the top of the forearm anchor piece. The bottom surface of the forearm dovetail is finished to be flush with the bottom surface of the receiver dovetail anchor and the 0.235" deep × 0.375" diameter counterbore is machined, completing the work sequence for both of the dovetail parts. The forearm support stud is now finished by installing it into the forearm dovetail anchor screw thread provided for it and is *Loctited* in place. The required clearance hole through the rod is now drilled, completing the part.

The scope mount (Part 37) for the rifle is machined out free-machining mild steel. It is taken out of a 6.0" long × 3.00" diameter bar. The central "barrel diameter + 0.002" diameter" is drilled and bored eccentrically, with the workpiece mounted in a four-jaw chuck. Then comes some band sawing to rough out the 3.25" long




Material: Cold rolled steel.
STOCK BOLT
PART 30

RECEIVER DOVETAIL
ANCHOR
PART 31

1. Material: Cold rolled steel.
2. Case-harden: 0.010" case depth.

FOREARM ANCHOR SCREW
PART 33
Alter standard 1/4-28 UNF hex head cap screw.

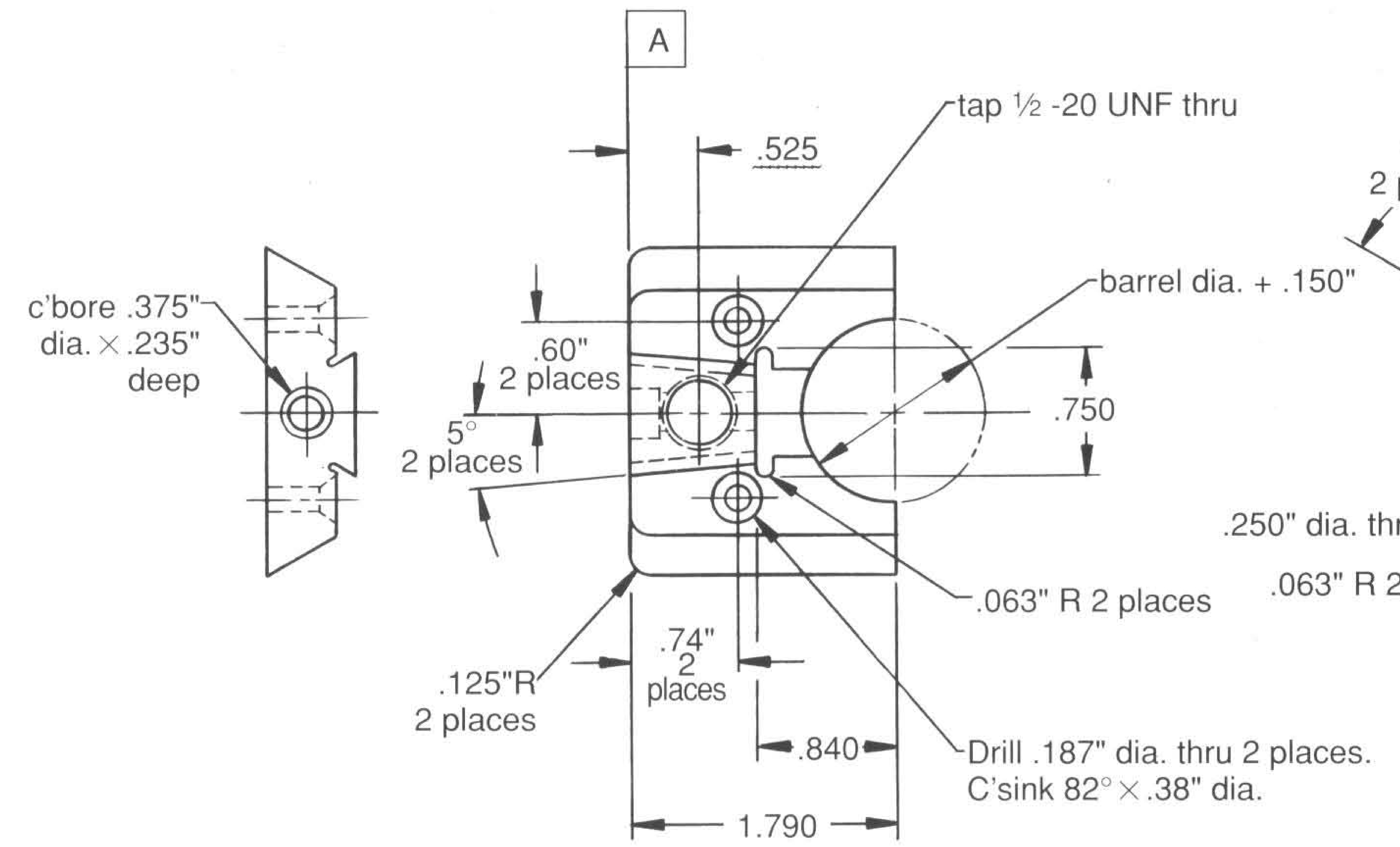
RECEIVER DOVETAIL
ANCHOR SCREW
PART 34
Standard 8-36 UNF hex head cap screw.

central dimension, and the workpiece can be moved to the milling machine. The transverse contour of the scope mount is formed entirely by milling. The part is best machined on a tight-fitting arbor, with the workpiece screwed to the arbor in two places, through holes drilled in the "window" areas of the scope mount. The arbor is mounted between centers in a dividing head or vertical turntable setup, with the outboard end of the part supported on a tailstock center.

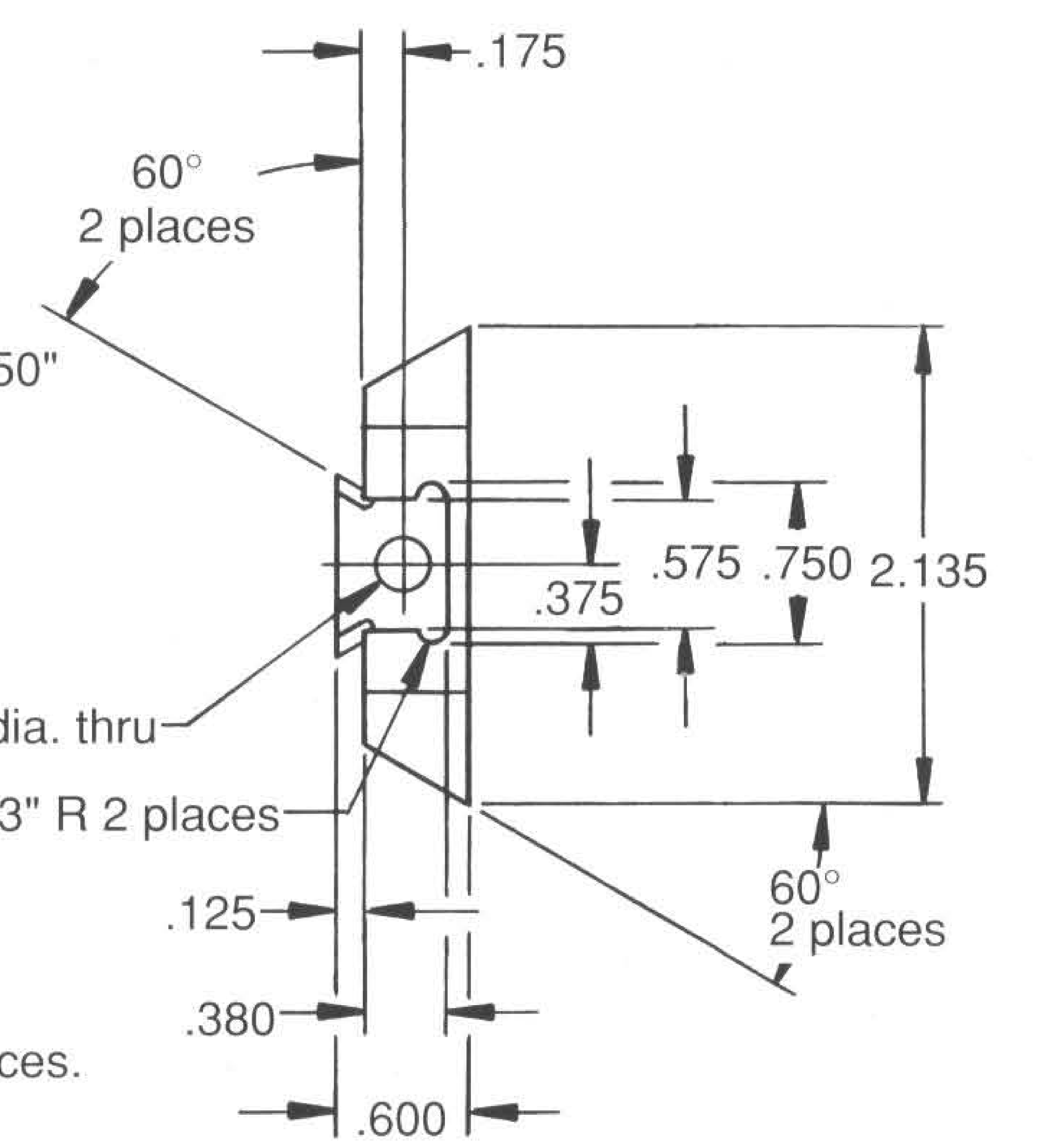
Do not use a chuck mounted on the dividing head to hold and rotate the part. Chucks have a perverse habit of vibrating loose when off-center machining cuts are taken with them. It takes many longitudinal passes of the milling cutter, with the workpiece being rotated about 3° per pass, to form the transverse contour of the scope mount. The mill-drill I bought did not come equipped with a longitudinal power feed, so I cranked the table by hand. When I finished my first rifle, the next serious job I undertook was to design and build a power feed mechanism for this machine, maybe quite understandably. But, anyway, it can be done by hand-cranking, and eventually you'll get it contoured, which is when you will form the details of the upper part of the scope mount. That gets to be a fun job, as the scope mount takes final form, and when you get to the point where you are milling the four windows, you get downright eager to work the job.

When the workpiece is no longer screwed to the arbor, make sure to clamp the part securely to the arbor with a parallel clamp or two. Next, rotate the part to the proper orientation and counterbore the starting surfaces for the three clamp screws. Center drill the locations, drill to 1/2"depth with a No. 29 (0.136" diameter) drill, and enlarge the hole to 17/64" diameter, drilling just deep enough to provide a full diameter for a 17/64" diameter flat-bottom drill to work. Then flat-bottom drill to form the counterbore, and complete the drilling of the No. 29 drill hole to the proper depth. Watch what you are doing here, because if the drill bulges the surface or breaks through, it won't necessarily scrap the part, but it will ruin your day.

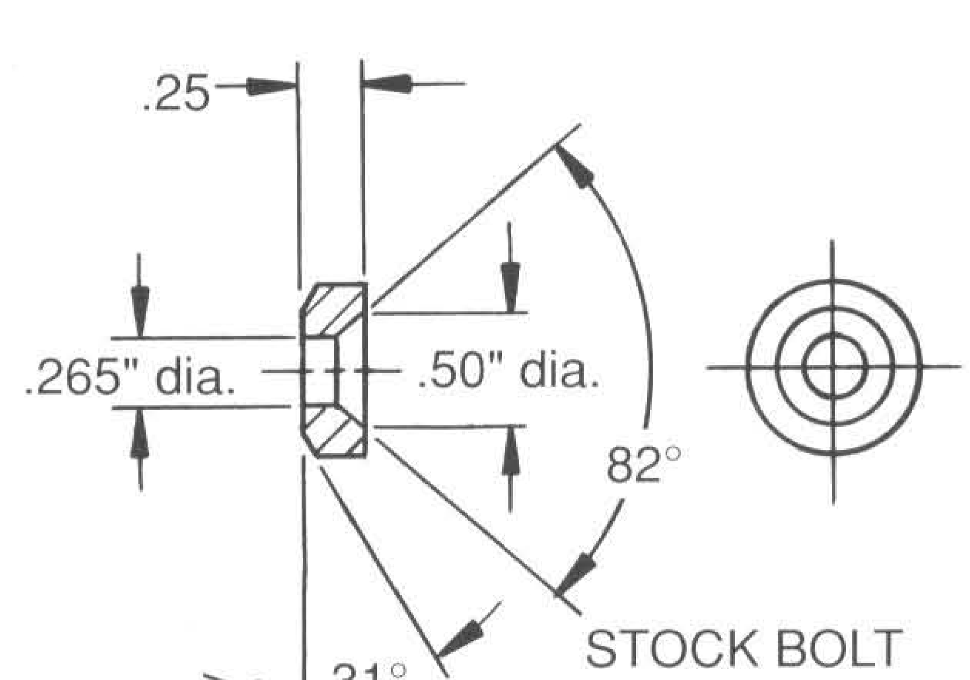
Now, you are ready to slot the part, which is easy enough. Again, make sure the work is securely clamped to the arbor and start the saw cut. I used a 0.057" wide saw, but there is nothing magic about that width. I just thought it looked nice.




1. Material: Cold rolled steel.
2. Case-harden: 0.010" depth of case.
3. Machine 60° tapered dovetail to size such that surface $\boxed{A}$ on Parts 31 and 32 is flush with parts screwed snugly together.

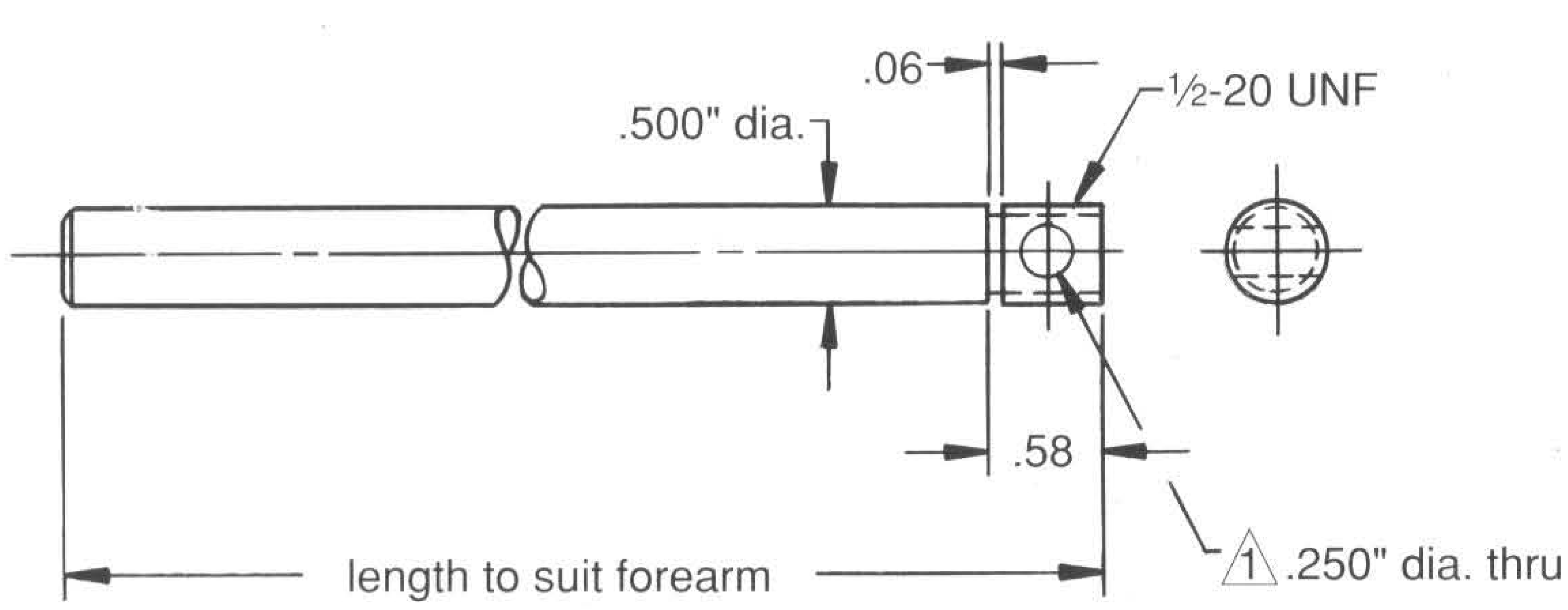



FOREARM DOVETAIL
PART 32




STOCK BOLT WASHER
PART 35

Material: Cold rolled steel, ¾" dia.




FOREARM SUPPORT STUD
PART 36

⚠1 Install to Part 32 to locate hole.
Material: CRS rod.

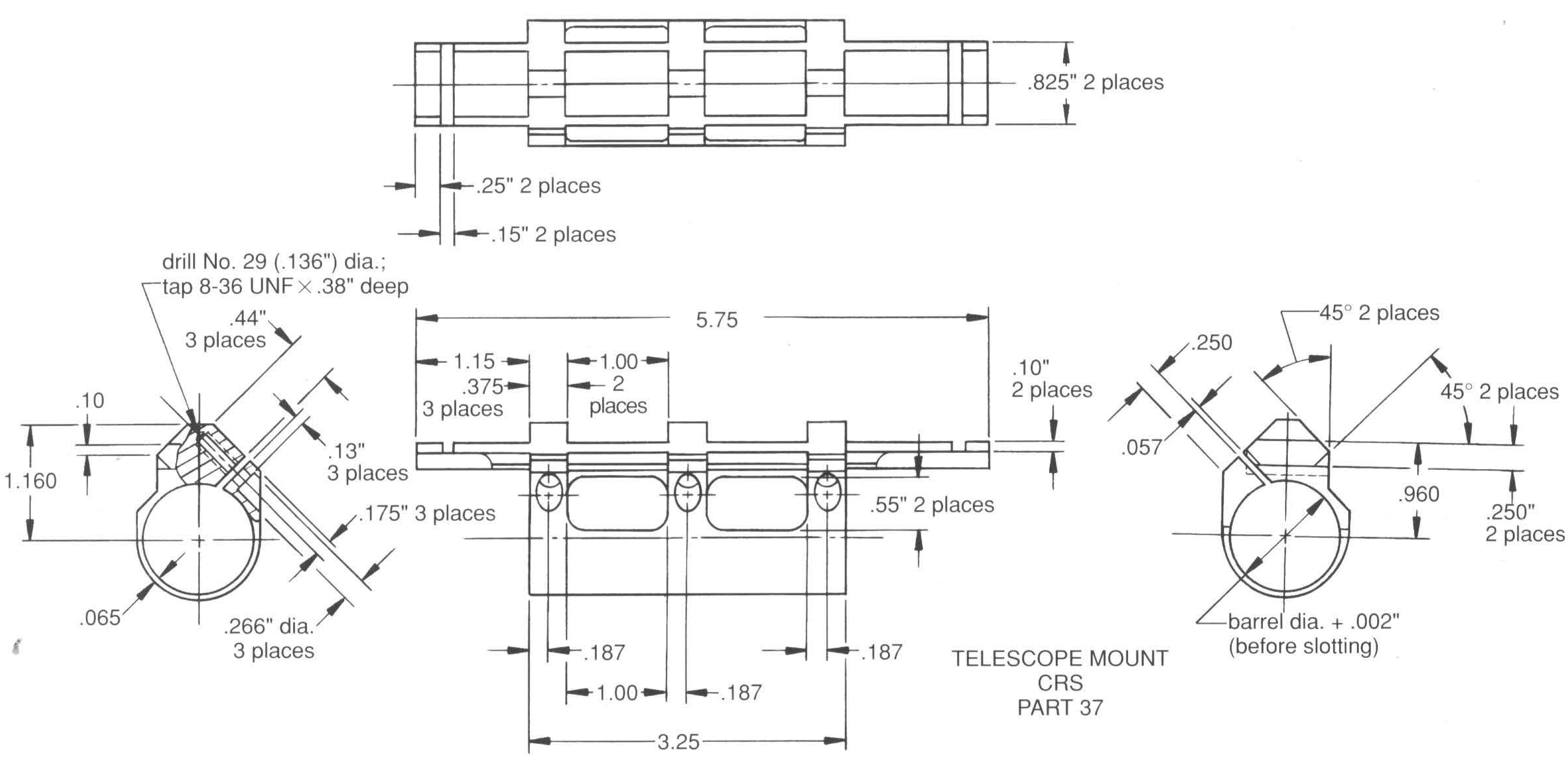
Open up the 0.136" diameter holes to 0.170" diameter to a depth only through the saw slot. Next, don't do what I did. I broke an 8-36 UNF tap in the first hole I tried to tap. It was the only tap I broke during the entire project. But, I found a small tool shop, where, for a $20 fee, I got the tap burned out. I can't complain, however, as the man who removed the broken tap finished tapping the first hole and also tapped the remaining two, throwing in the tap he used in the bargain.

Now, are you ready for this? You are nearly finished with your rifle action. Only a couple of small details remain to be done.

Assemble the entire action. You are now going to decide how much trigger travel you like before the action fires. Usually, if the trigger travel adjust screw is left too long, the trigger sear will not engage the striker sear and the action will not cock. If that's the case with your action, the remedy is obvious. Sometimes, the trigger does cock but gives virtually no trigger travel at all before releasing, which is a dangerous condition. I recommend the trigger move 0.03" to 0.04" before releasing. You may not like that amount, so you'll have to experiment a little to get the travel you like.

One more "last" detail is required. This is the mounting of the safety button on the safety lever. You have drilled the 2-56 NC tap-drill hole through the safety lever, but have not countersunk for the flathead screw. This was left so you could draw file or surface grind and polish the bottom surface of the receiver, taking off some or all of the 0.003" of finishing stock left on that surface. Do the finishing and polishing now. When you are satisfied with your polish, retrieve your safety button. With the safety button flush to the bottom surface of the receiver and engaged with the safety lever, transfer punch the 2-56 NC screw hole location to the safety button. Drill and tap for the 2-56 screw, and then finish the 82° countersink on the proper side of the safety lever.

Now, for the "last" last detail. You have noticed from the detail drawing of the breech block the depiction of a "loading groove" in the top contour of the block. This is necessary because the breech block travel does not completely uncover the chamber opening in the barrel. The drawing shows a 7/16" diameter groove machined centrally in the top surface of the block. I have not mentioned this earlier as the first mention of chamber sizing occurred when you chambered the stub barrel. Even then, there was no mention of what cartridge the chamber was to accept. Depending on cartridge rim diameter, the chamber opening varies in diameter, and so the loading groove varies in depth. The detail drawing of the extractor uses the example of the caliber .225 Winchester case to determine its critical dimensions. If you are chambering for a case different from the .225 Winchester, you'll have to do your own calculations. So too, you'll have to determine what depth the loading groove has to be, to allow the cartridge to easily enter the chamber. But when the loading groove is machined, the machine work on the action is finished.




TELESCOPE MOUNT
CRS
PART 37

**REFLECTIONS**

Many people may criticize me, justifiably, for designing and building another firearm. Clearly the world needs fewer weapons than are presently available. But, I did not design and build, nor intend that this project should be, a weapon. For me it was a challenge, both in the design and the mechanical construction, as well as the use of the finished rifle. I am a target shooter, who, like many others engaged in different sports, is challenged to see how well I can train myself to perform in my specialty activity. In my lengthy association with this sport, I have been thrown into contact with many other shooters, whose motives and actions could not be further removed from mine. It is my certain conviction that a fair percentage of these enthusiasts should never have owned a firearm. All too often, they showed up on the firing line of the shooting range equipped with military-style assault rifles, and endeavored only to release a maximum poundage of lead in a minimum amount of time. I sincerely hope this project will not appeal to those persons. I do offer it to those craftsmen who appreciate the results of their skill and knowledge, and who are capable of using their rifle to its and their capacities.

I will make some further unqualified assertions. Do not attempt to do your own heat-treatment on the major, stress bearing components of this action. You need the services of a competent heat-treatment specialist, who has the equipment and quality control procedures to ensure that the detail design callouts will be met. And, if you wish to chamber this action for cartridges having body diameters larger than the .225 Winchester case, I would heartily recommend that you recalculate the tangential stress levels that will appear at the barrel shank, using the calculation methods illustrated in the "Mathematical Analysis" section of this presentation. It is my intention that every safety consideration be understood and employed by anyone who undertakes the manufacture of this action. Please know what you are doing before you do it!

## EXCERPTS FROM *The Federal Firearms Regulations Guide*

*1988-89, Page 83*

**Question (A7):** DOES THE GCA (Gun Control Act of 1968 as amended) PROHIBIT ANYONE FROM MAKING A HANDGUN, SHOTGUN, OR RIFLE?

*A Title I (sporting-type) firearm can be made by a nonlicensee provided it is not for sale or distribution, and the maker is not prohibited from possessing firearms...*

**Question (A9):** AN UNLICENSED INDIVIDUAL WISHES TO MANUFACTURE A PROTOTYPE FIREARM. DOES HE NEED A LICENSE?

*A prototype firearm may be manufactured without its maker being licensed under the Gun Control Act of 1968, provided the firearm is not for sale or distribution. The making of a "firearm" as defined by the National Firearms Act is subject to ATF approval, and to the tax and registration requirements of the act.*

---

NOTE: The above refers to a sporting firearm, as the single-shot action in the article would be the main part of when completed. When finished, the rifle has to have a barrel over sixteen (16) inches in length and must have an overall length greater than twenty-six (26) inches. Most readers will not have any problems with the legalities of making a single action for their own use. If there is any question about who can own a firearm, examine the questions on ATF Form 4473. This form is available at any gun dealer or from ATF themselves.

To check on your specific state regulations, examine a copy of *State Laws and Published Ordinances – Firearms* (19th edition or more recent, ATF publication P 5300.5, 12/89). A copy may be available at your local library, or contact your State's Attorney General office for the information.

It is recommended by ATF that there be a unique marking on the receiver to identify the weapon in case it is lost or stolen. The unique marking can be your last name and the date, but it should be placed on the main part of the receiver (Part 1 in this article).

You may not make a weapon for resale (even giving it away) without having a manufacturer's license. This is interpreting the regulation as conservatively as possible. The maker may will the weapon to an heir. If there are any further questions or if you cannot find a local BATF (Bureau of Alcohol, Tobacco, and Firearms, Department of the Treasury) office, try the BATF Main Office in Washington, D.C., at (202) 927-7777.

*Kevin Dockery*